Iron and Steel ENGINEER

ENGINEERING SERVICE
TO THE IRON AND STEEL
INDUSTRY SINCE 1907

1010 EMPIRE BUILDING August, 1943 PITTSBURGH, PA.

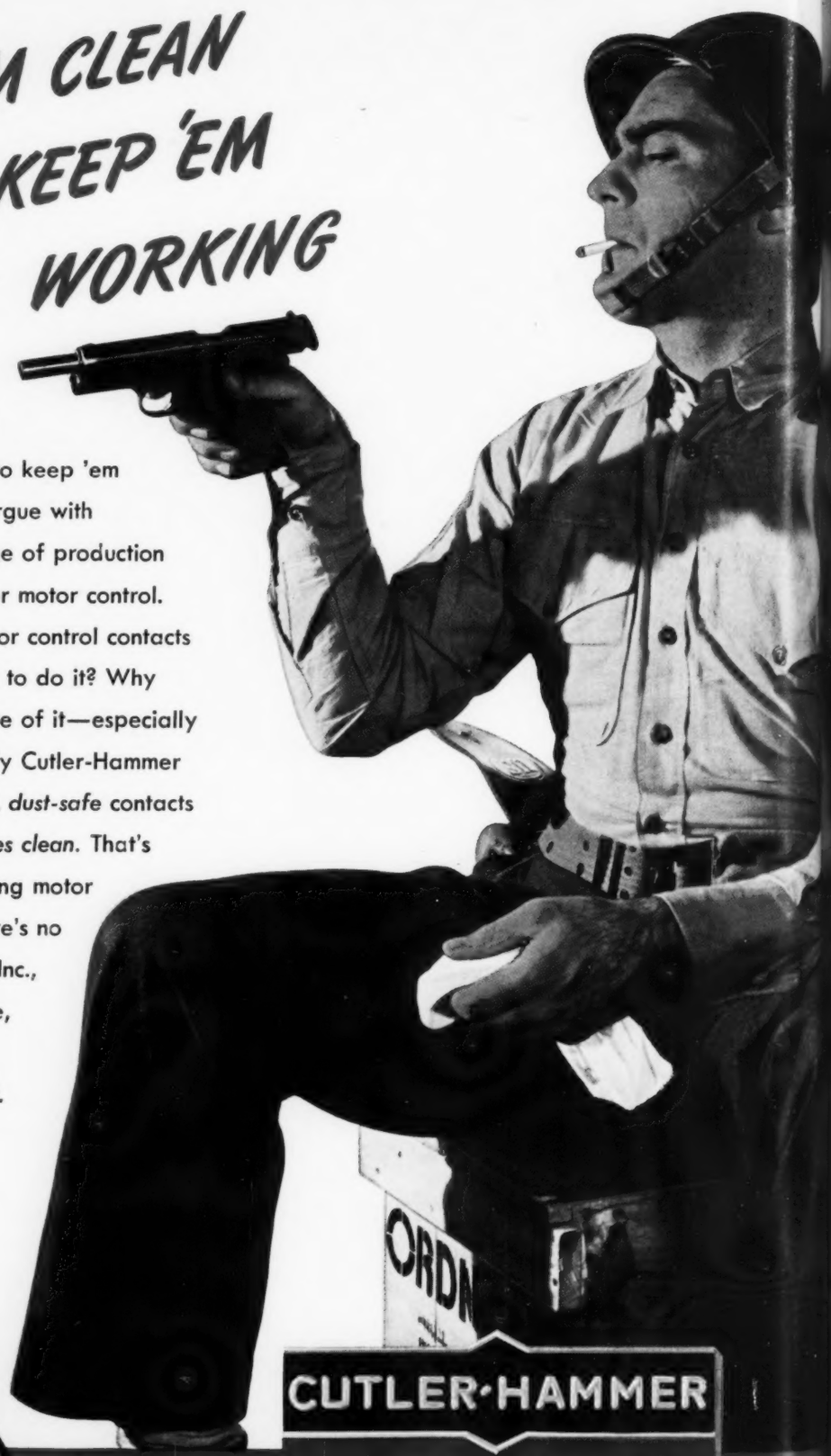
TECHNOLOGY DE
LIBRARY
1943
DETROIT

MESTA
FORGINGS

One Piece Forged Steel
High Pressure Accumulator Bottle
Produced Complete in the Mesta Plant

MESTA MACHINE COMPANY . PITTSBURGH, PA.

KEEP 'EM CLEAN TO KEEP 'EM WORKING



You don't have to argue with a man up at the front that it's just good sense to keep guns clean to keep 'em working. Nor do you have to argue with experienced men on the front line of production that the same thing holds true for motor control. Of course you *have to* keep motor control contacts clean . . . but *how* are you going to do it? Why make an *extra* maintenance chore of it—especially when men are so scarce? Specify Cutler-Hammer Motor Control with the VERTICAL *dust-safe* contacts that *shed* dirt and *keep themselves clean.* That's the direct way of insuring unfailing motor control performance . . . and there's no extra cost. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Cutler-Hammer Vertical Contacts

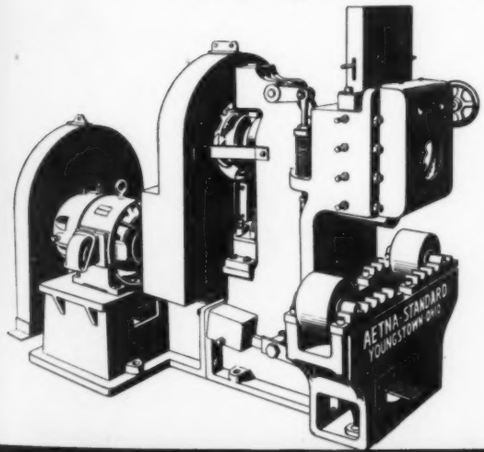
OUT IN THE OPEN—NOTHING TO HIDE—You can see the clean contacts in Cutler-Hammer Motor Control as soon as you open the case. They're out in the open where they can work cooler and last longer.

Copyright 1943, Cutler-Hammer, Inc.

SYMBOLS OF FREEDOM

From baking an apple pie to building a bomber is quite a step but American women have made it look easy. Thousands of industrial plants are finding that women efficiently fill the gap caused by the shortage of manpower. This has proven to be true in many types of civilian work and their voluntary service in the military field has released many men for combat duty.

In the reconstruction period that follows, these same women will again take their places in maintaining the American Home—the foundation of everything for which we fight.



The AETNA VERTICAL STRAIGHTENING PRESS for round or square bars. Available in various capacities, clutch operated to strike intermittently or continuously.

ARMY E NAVY

The AETNA-STANDARD ENGINEERING COMPANY
YOUNGSTOWN, OHIO, U.S.A.

★

DESIGNERS AND BUILDERS TO THE STEEL, NON-FERROUS AND CHEMICAL INDUSTRIES

ASSOCIATED COMPANIES:
HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

"AUTOMATICS"

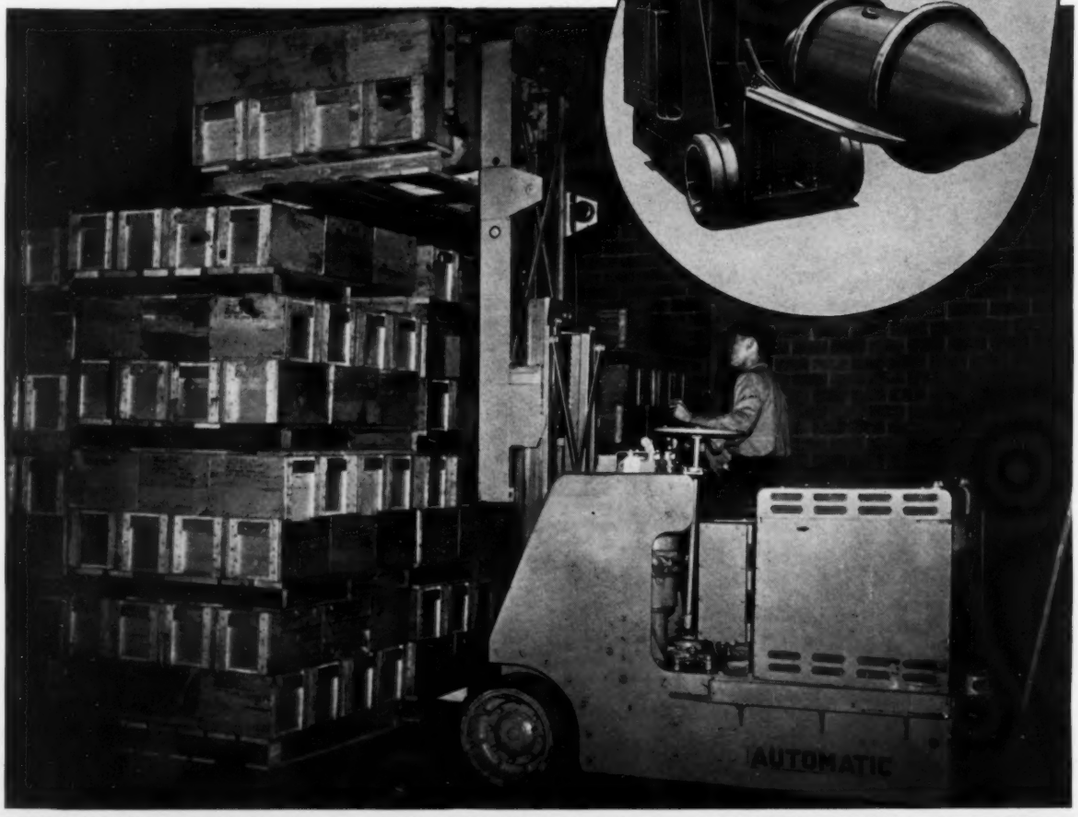
All of us are working for a quick victory

★ You in your way—we in ours—are extending ourselves to the limit to shorten the road to victory.

It is obvious that materials handling is a most important part of the war effort and to us is assigned the task of getting materials handling equipment to those places where it will do the most good.

Naturally we regret the situation that makes it necessary for so many of our customers of long standing to be denied new "AUTOMATICS" for the present. Yet, all of us are happy to cooperate in our own way for in this united action comes victory. One of these days there will come an end to the "for the duration" period and "AUTOMATICS" will again be available. Meanwhile, since we are "all out for war production" and your victory efforts too are being contributed—keep your "AUTOMATICS" going to keep materials flowing.

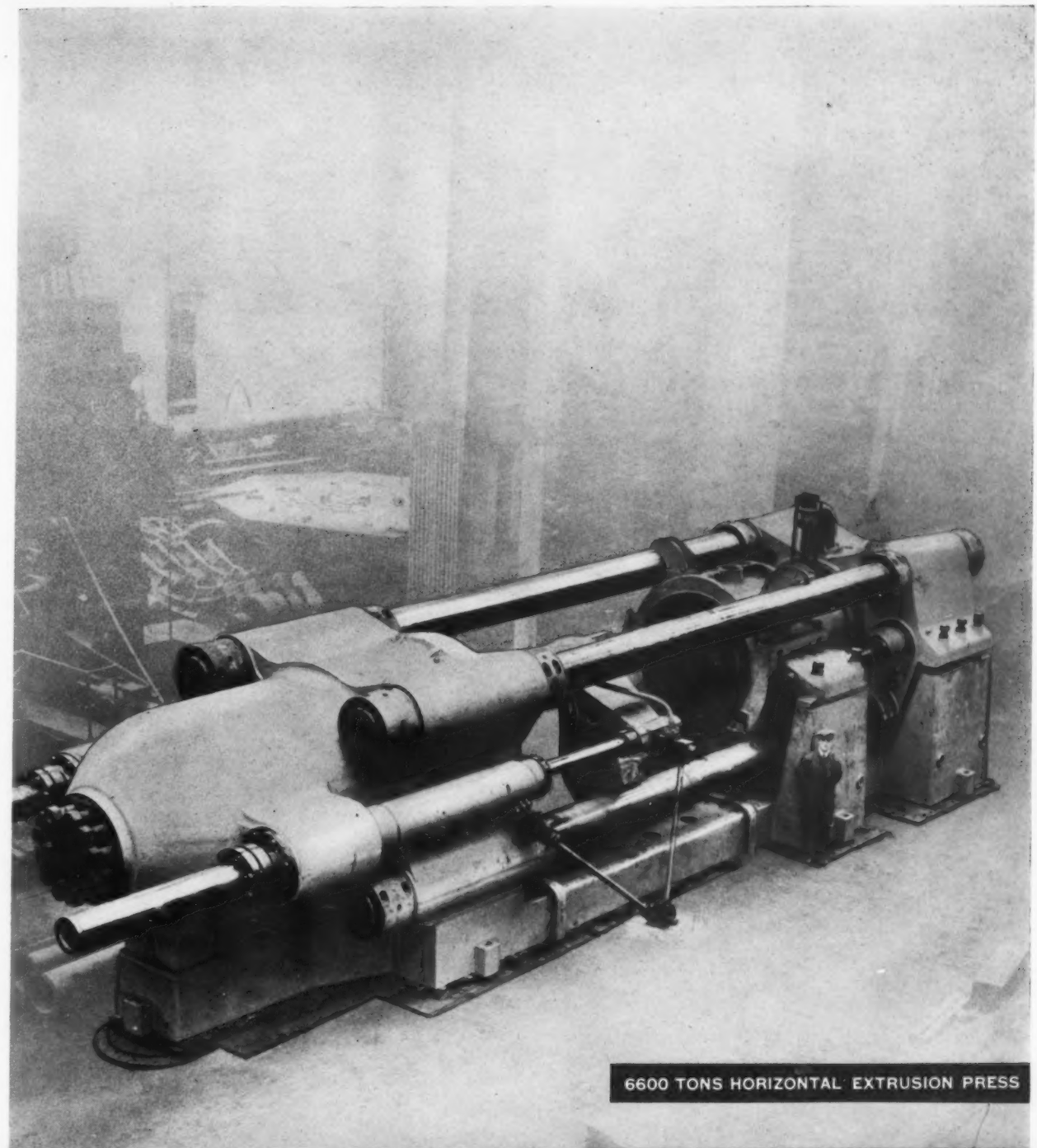
"Pass" THE AMMUNITION



MANUFACTURERS FOR OVER THIRTY FIVE YEARS *Electric Propelled* INDUSTRIAL TRUCKS

AUTOMATIC TRANSPORTATION CO.

47 WEST 87th STREET DIV. OF THE YALE & TOWNE MFG. CO. CHICAGO 20, ILLINOIS


6600 TONS HORIZONTAL EXTRUSION PRESS

HYDROPRESS · INC.

ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS
PUMPS · ACCUMULATORS

570 LEXINGTON AVENUE · NEW YORK · N. Y.

WHAT ONE COMPANY DID:
JULY '36 — SHOP "A" ORDERED.....10 PITS
NOV. '36 — SHOP "A" ORDERED..... 5 PITS
JULY '41 — SHOP "A" ORDERED.....10 PITS
JULY '41 — SHOP "B" ORDERED..... 5 PITS
JAN. '43 — SHOP "A" ORDERED..... 5 PITS
FEB. '43 — SHOP "C" ORDERED..... 8 PITS
43 PITS IN ALL!

SURFACE

MANUFACTURERS OF SC INDUSTRIAL FURNACES

"Proof of the Pudding is in the eating thereof..."

and proof of the *superiority of Surface One-way-fired Soaking Pits is in their overwhelming acceptance by practical steel men

● Theories come and theories go...but it's the practical, efficient, results-producers that endure. That's the way it is with soaking pits.

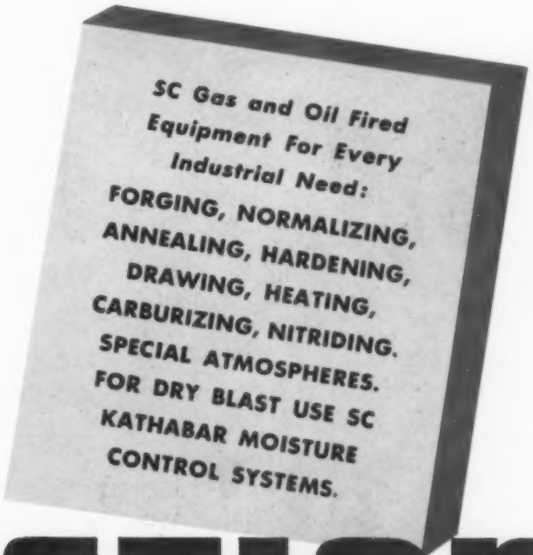
With one steel company, for instance, ten Surface One-way-fired Soaking Pits were installed. They proved their superiority, produced desired results. Then more SC pits went in...not one repeat order, but five times. This has happened again and again...in shop after shop. It is truly the "proof of the pudding."

If you want to see how SC pits operate—how they do more work, better work, at lower cost—just accept our invitation to come and watch them in actual service.

Invariably, steel men who see these pits hard at work in the production of steel for war, come away convinced that these tried-and-proved one-way-fired pits are tops.

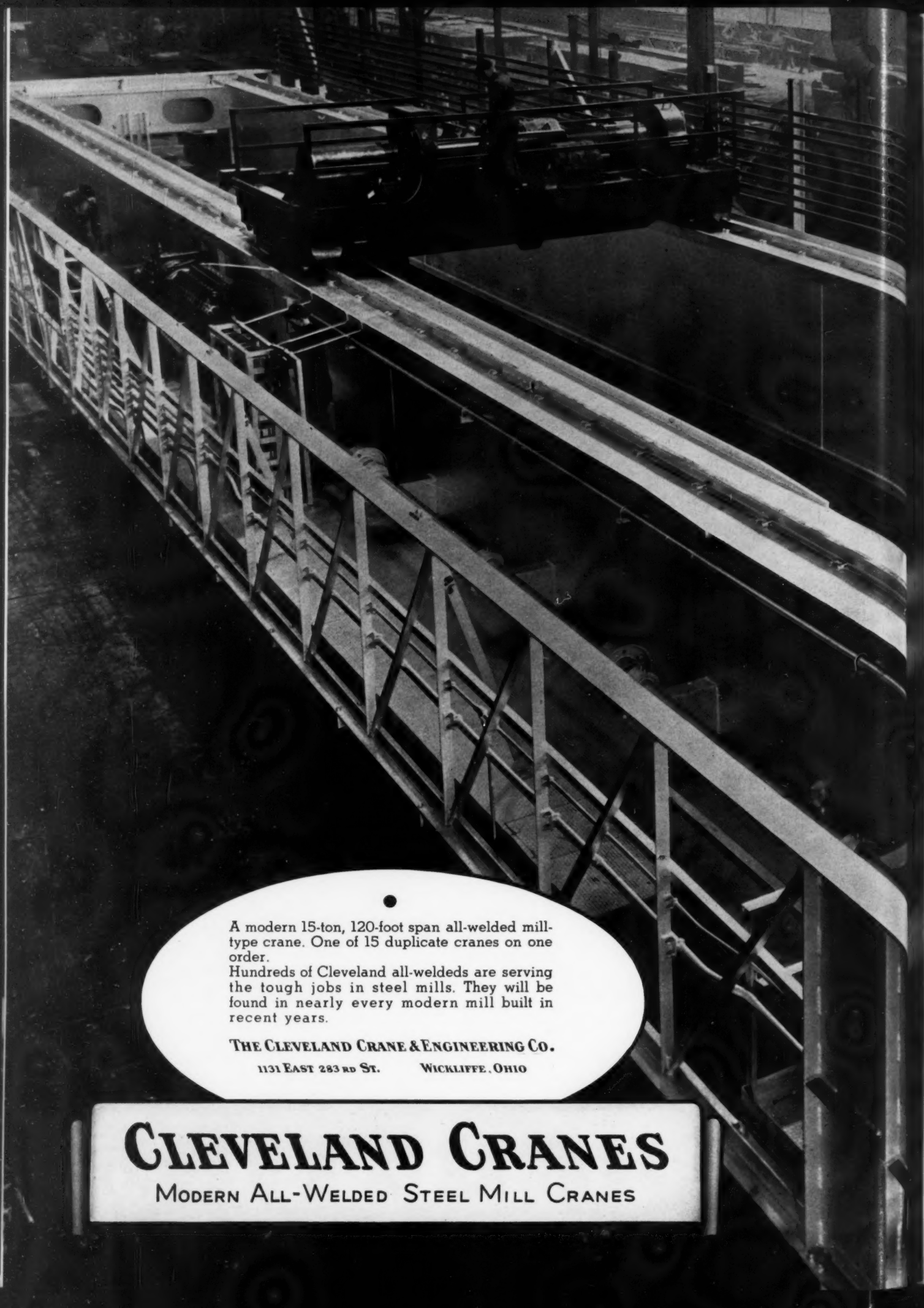
***Simplest Construction**
***Greatest Capacity**
***Most Efficient Firing**
***Best Heat Distribution**
***Lowest Maintenance**

SURFACE COMBUSTION · TOLEDO, OHIO


SC Gas and Oil Fired Equipment For Every Industrial Need:
FORGING, NORMALIZING, ANNEALING, HARDENING, DRAWING, HEATING, CARBURIZING, NITRIDING, SPECIAL ATMOSPHERES.
FOR DRY BLAST USE SC KATHABAR MOISTURE CONTROL SYSTEMS.

COMBUSTION

JANITROL GAS-FIRED SPACE HEATING EQUIPMENT · KATHABAR SYSTEMS FOR DRY BLAST



A modern 15-ton, 120-foot span all-welded mill-type crane. One of 15 duplicate cranes on one order.
Hundreds of Cleveland all-weldeds are serving the tough jobs in steel mills. They will be found in nearly every modern mill built in recent years.

THE CLEVELAND CRANE & ENGINEERING CO.

1131 EAST 283 RD ST. WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

JOHN T. WHITING, new chief of WPB Steel Division announced that the first week of the "Share the Steel" drive recovered 75,000 tons of steel for reallocation. Subsequent reports have brought this figure to over 800,000 tons. There is no physical removal of inventory in this plan, but only the changing of some steel allotments for reallocation to users needing the material.

▲

WHEN liquor rationing comes, who is to decide whether a man is an A-card drinker or a C-card drinker? Or whether a man is drinking for pleasure or business? Or what grounds are sufficient for supplemental rations?

▲

CONTINUOUS x-raying of castings has reached the mass production stage with a new machine capable of inspecting 17,000 castings in a 24 hour day. Castings move along a conveyor on trays that halt automatically under the x-ray tubes, and castings are inspected at the rate of one every five seconds — assembly line speed for x-ray inspection.

▲

BRITISH-AMERICAN cooperation in the metallurgical field has brought out the fact that the British plants have been using richer alloys than have the American plants to obtain comparable physicals, because of their practice of quenching in oil instead of in water. On the other hand, British alloy recovery methods are superior to ours. English plants recover 41 per cent of their molybdenum and 58 per cent of their nickel, against corresponding figures of 36 and 45 per cent in American practice. It has been recommended that seven grades of alloy turnings be segregated, color graded and marked. Greater use of the ternary Cr-Mo-Ni alloys is also urged.

▲

STYLES change in feminine sayings:

1941—"What a man!"
1942—"What? A man?"
1943—"What's a man?"

▲

ONE of our readers writes in to advise us that a conference is a group of men who, individually, can do nothing, but who, as a group, can meet and decide that nothing can be done.

A NUMEROLOGIST might make something out of the pig iron production for the first half of 1943, 30,343,443 tons — certainly a poker player or crap shooter could. All we can make of it is an increase of 912,572 tons over the corresponding period of last year, while enough capacity was added to produce 1,553,775 tons, reflecting more shutdowns for furnace repairs, etc.

▲

ROLLED steel products for the first half of this year totaled 33,245,073 net tons. Of this total, bars form the largest item, 6,504,598 tons, with an indicated operating rate of 89.2 per cent of capacity. Close behind are plates with 6,399,825 tons, for an operation of 140.4 per cent of capacity. Sheet production, with 4,340,519 tons produced, shows an operation of only 64.8 per cent of capacity.

▲

THE average number of hours worked per week by all wage-earning employees in the steel industry during June was 43.3, compared with 41.9 in May and 38.7 in June of last year.

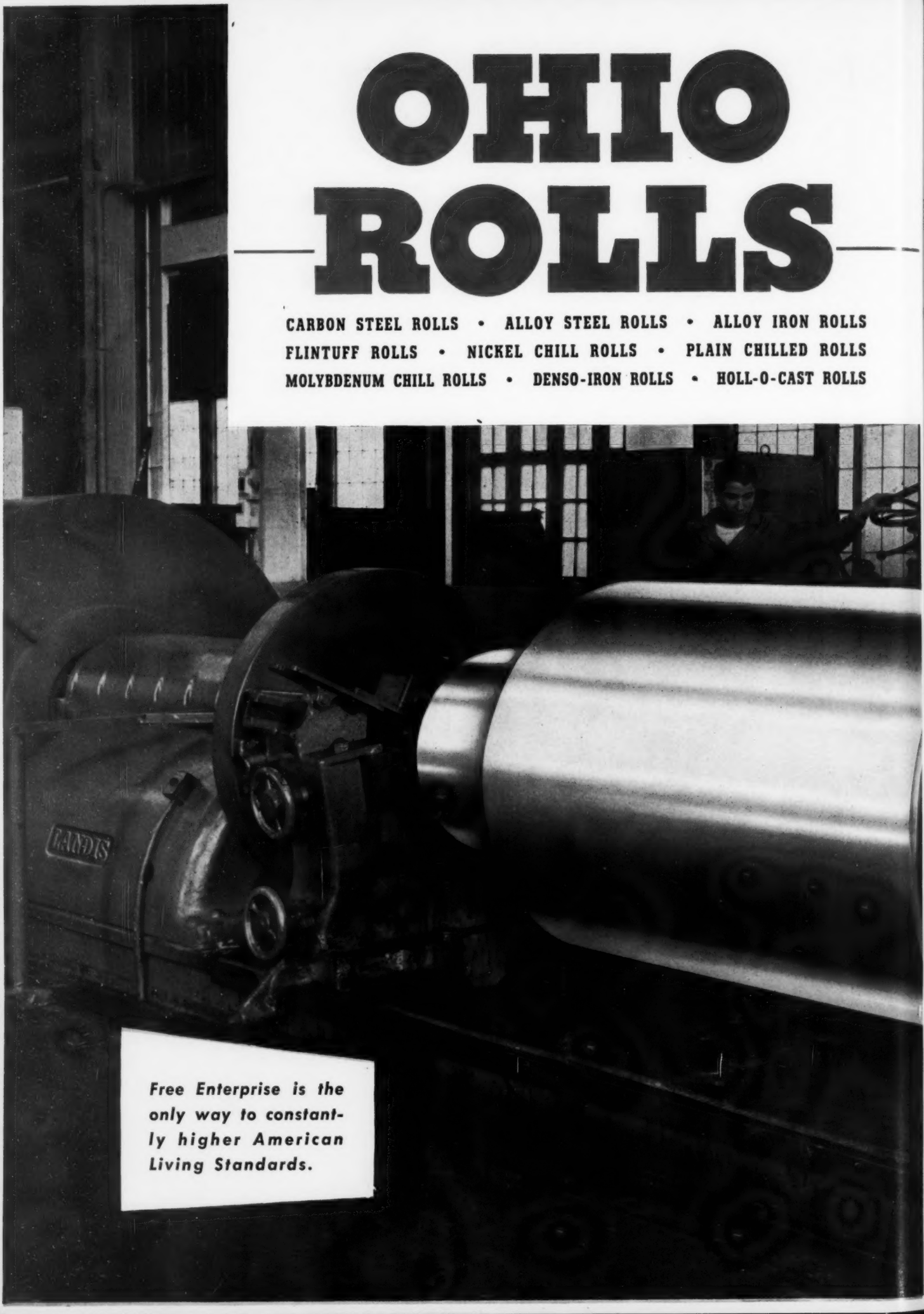
▲

A RESEARCH program, sponsored by steel and iron ore interests, will be carried out at Battelle Memorial Institute, Columbus, Ohio, to attempt the development of a practical, low cost method of separating silica from iron oxide, thus making the great reserves of low grade hematite in the Lake Superior fields more suitable for our prevailing practice.

▲

THE poster reproduced below is one of the General Cable Corporation's program. The message it carries is by William S. Porter, an employee of the company. We think it speaks for itself.

DARE YOU TO SAY OR THINK YOU DO NOT FEEL
THE BULLET THAT HAS PIERCED THE FLESH OF HIM
WHO FOUGHT SO GALLANTLY, WITH FIERY ZEAL,
WHILE THINKING NOT OF LOSS OF LIFE OR LIMB?
DARE YOU DENY TO THOSE WHO ENTER HELL,
FOR WAR IS HELL FOR ALL OUR FIGHTING CREW,
THE HOURS OF STICKING ON YOUR JOB? THINK WELL -
FOR IF YOU DARE, THEN WE ARE LOST... AND YOU!



OHIO ROLLS

CARBON STEEL ROLLS • ALLOY STEEL ROLLS • ALLOY IRON ROLLS
FLINTUFF ROLLS • NICKEL CHILL ROLLS • PLAIN CHILLED ROLLS
MOLYBDENUM CHILL ROLLS • DENSO-IRON ROLLS • HOLL-O-CAST ROLLS

Free Enterprise is the only way to constantly higher American Living Standards.

ACCURATE
RELIABLE
DURABLE

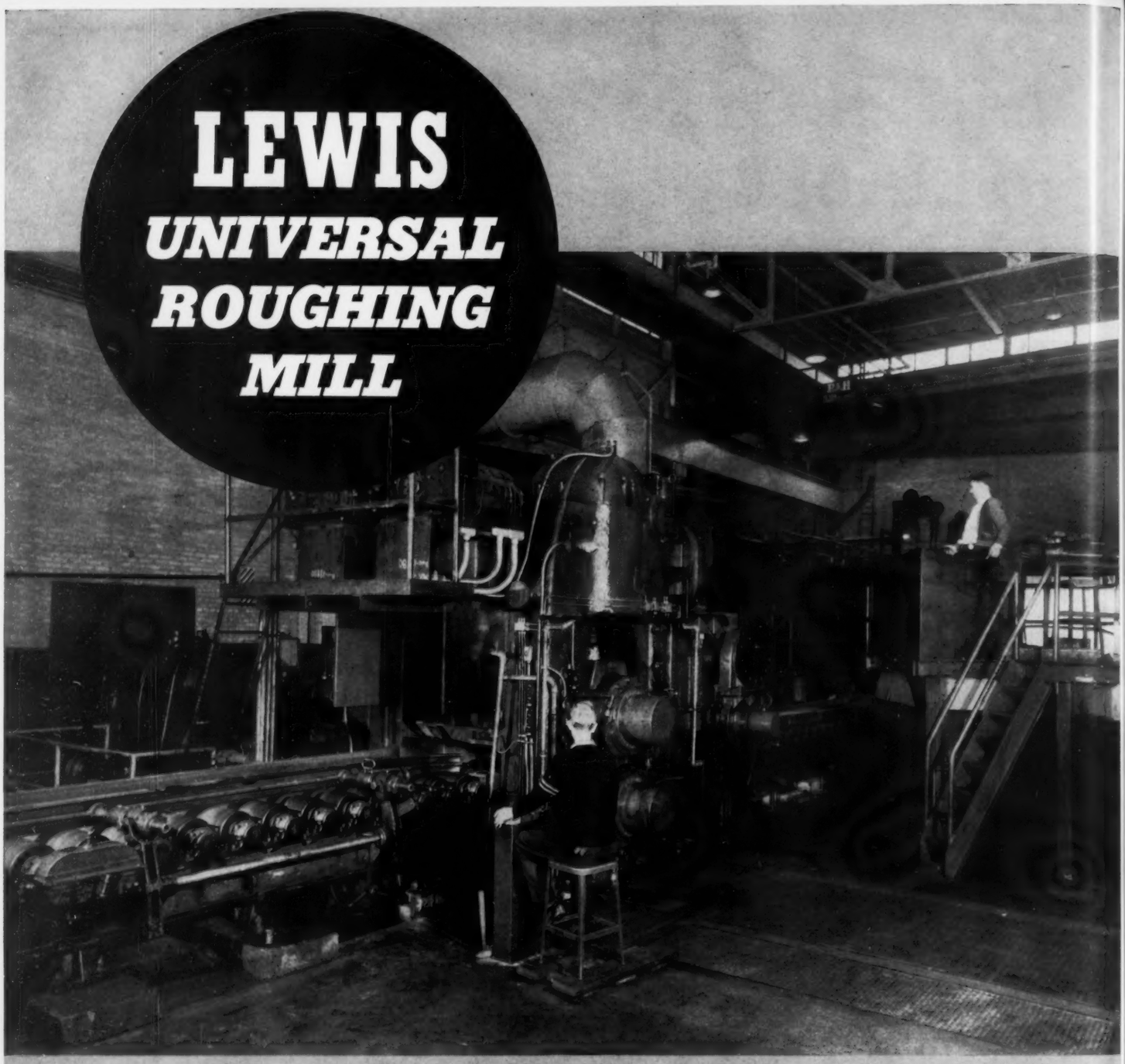
THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO • SPRINGFIELD, OHIO

ENGINEERS • FOUNDERS • MACHINISTS

THE LEADER IN IMPROVED ROLL MANUFACTURING TECHNIQUE

LEWIS
UNIVERSAL ROUGHING MILL



This Universal Roughing Mill for non-ferrous materials is equipped with independent drive on the vertical rolls.

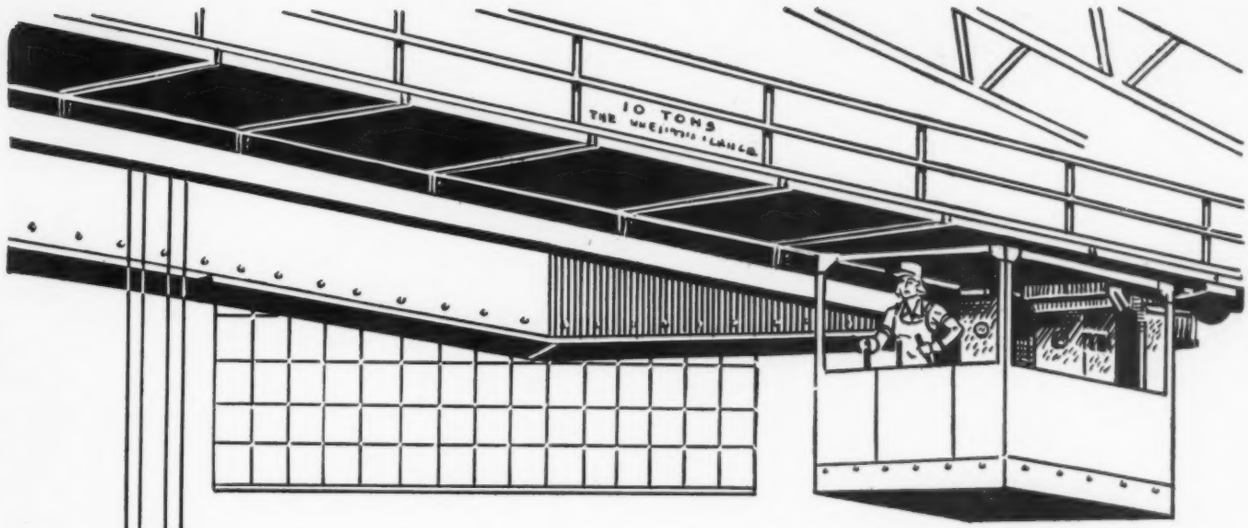
It is exceeding all expectations in producing products for the war program.

Let Lewis Rolls and Rolling mill machinery help you speed up production for victory.

ARMY E NAVY

LEWIS
Rolls and Rolling Mill Machinery step up tonnage

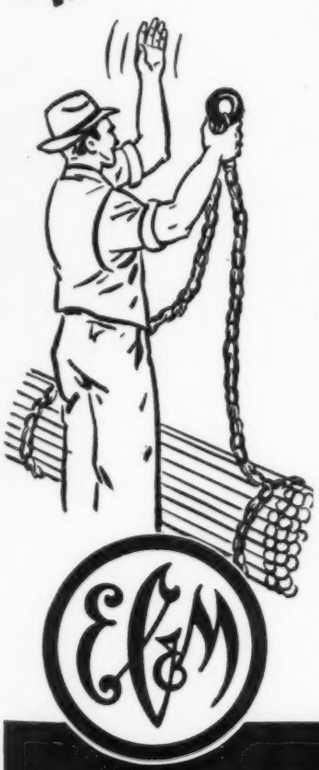
LEWIS FOUNDRY & MACHINE
DIVISION OF BLAW-KNOX CO.
PITTSBURGH, PA.



"HURRY UP SISTER!"

"I can't—it won't go—
Something's the matter with it!"

"I've got the controller-handle full on—and there's plenty of juice."



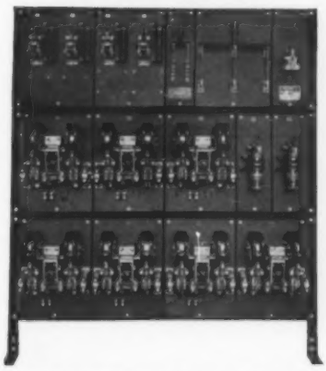
★ That's just the trouble, sister. You've got too much juice and are roasting that a.c. wound-rotor bridge motor. Back the control up toward the off point. That will reduce the current and put the motor-torque up where it belongs and get you going. The only way to handle a wound-rotor motor, operated by manual control, is to notch the control along, step by step, giving the motor a chance to get going between notches.

Now, if you had a magnetic control like the EC&M type, you could throw the master-handle full "on" without trouble, the EC&M Frequency Relays automatically taking care of acceleration and plugging for you.

This control protects the motor, too. For example, one was installed over a year ago on a foundry crane and since then there has not been a minute's delay, while on some of the other cranes in this plant, bridge motors last an average of only three months before they need rewinding.

Today, many carefully engineered cranes are equipped with EC&M Frequency Relay Magnetic Control, complete facts about which are given in Booklet 930. Write for your copy today.

Type of Master Switch used with Magnetic Control. Bulletin 1182, Type NT Master.



EC&M 37 H.P., 550 Volt A.C. Reversing-Plugging, Frequency Relay Magnetic Controller for Bridge Motion of overhead crane in steel mill.

THE ELECTRIC CONTROLLER & MFG. CO.

2700 East 79th Street ★ Cleveland 4, Ohio

TRAIN YOUR SIGHTS—

on a Larger Share in the Victory Effort

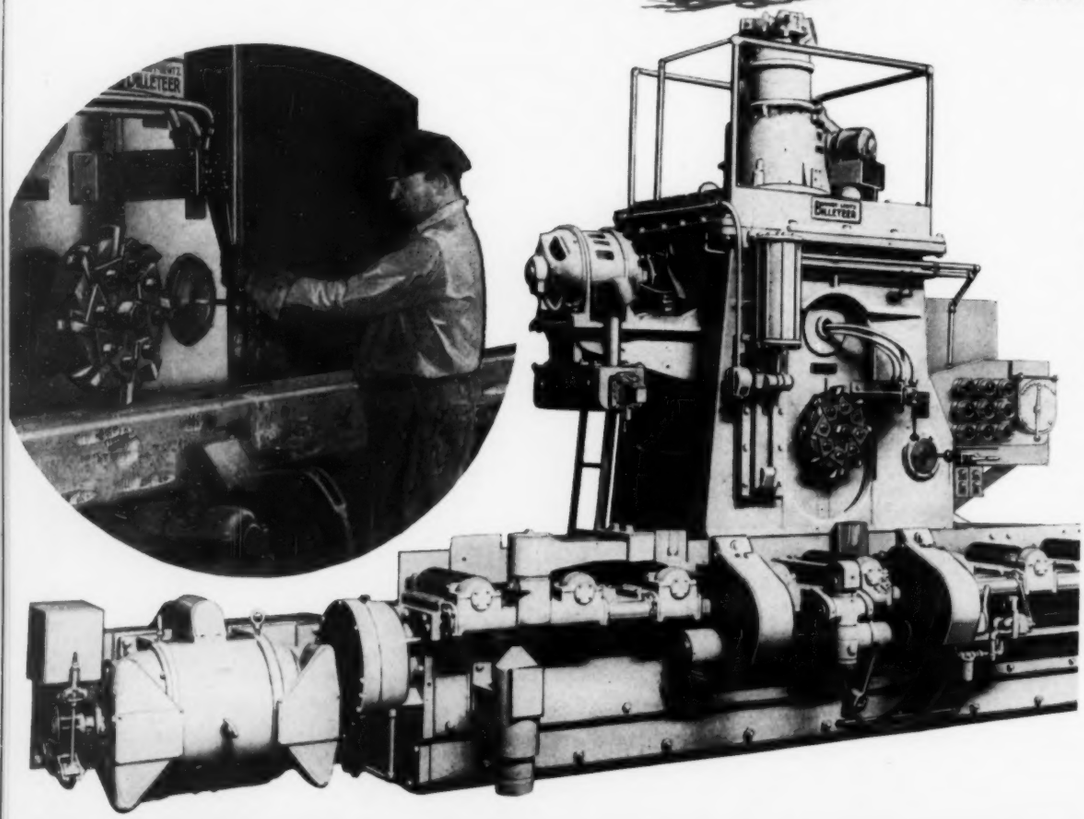
The more you produce for Victory — the more you can share in its benefits, for everything you do *now* to increase production and cut costs will aid you in post-victory problems. There are no more effective spots to start speeding up operations than in billet-chipping departments still bogged down with obsolete methods.

And the most effective way of really getting billets on the move is to install a Bonnot Billeteer. This mechanized billet chipper will speed up chipping as much as 90% . . . average a 50% saving on chipping costs . . . salvage billets unprofitable to clean by hand . . . and eliminate the "headache" of maintaining an adequate force of hand chippers.

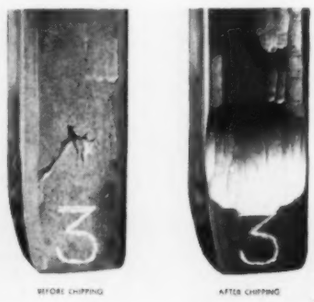
It will pay you to discuss your chipping department problems with one of our sales engineers.

WRITE FOR COMPLETE DATA

THE **Bonnot** COMPANY
STEEL EQUIPMENT DIVISION
CANTON, OHIO



The Billeteer will clean any class of steel which can be chipped by hand. It salvages billets which have deep defects unprofitable to remove by hand. The deep crowfoot in an 8 in. x 8 in. billet of chrome vanadium steel, shown by photo below, was removed in two minutes on a Billeteer, with a final cutting depth of 1 inch.



BEFORE CHIPPING AFTER CHIPPING

TIMKEN BEARING EQUIPPED

BONNOT-LENTZ

BILLETEER

A MECHANIZED SUPER PRODUCTION BILLET CHIPPER

The WEAN ENGINEERING COMPANY, Inc. • WARREN, OHIO

SPECIALISTS IN SHEET, TIN AND STRIP MILL EQUIPMENT

- HEAVY PLATE LEVELLERS
- HI-SPEED SHEET AND TIN MILL SHEAR LINES
- ELECTROLYTIC & BONDERIZING TIN PLATE EQUIPMENT
- WILSON TUBE ANNEALING FURNACES
- WEAN VACUUM CUP SHEET AND PLATE LIFTERS
- CONTINUOUS STRIP PICKLING, SLITTING, SIDE TRIMMING, AND RECOILING LINES

Associated Companies

LEE WILSON ENGINEERING CO. CLEVELAND, OHIO

FLINN & DREFFEIN CO. CHICAGO, ILL.

THE McKAY MACHINE CO. YOUNGSTOWN, OHIO

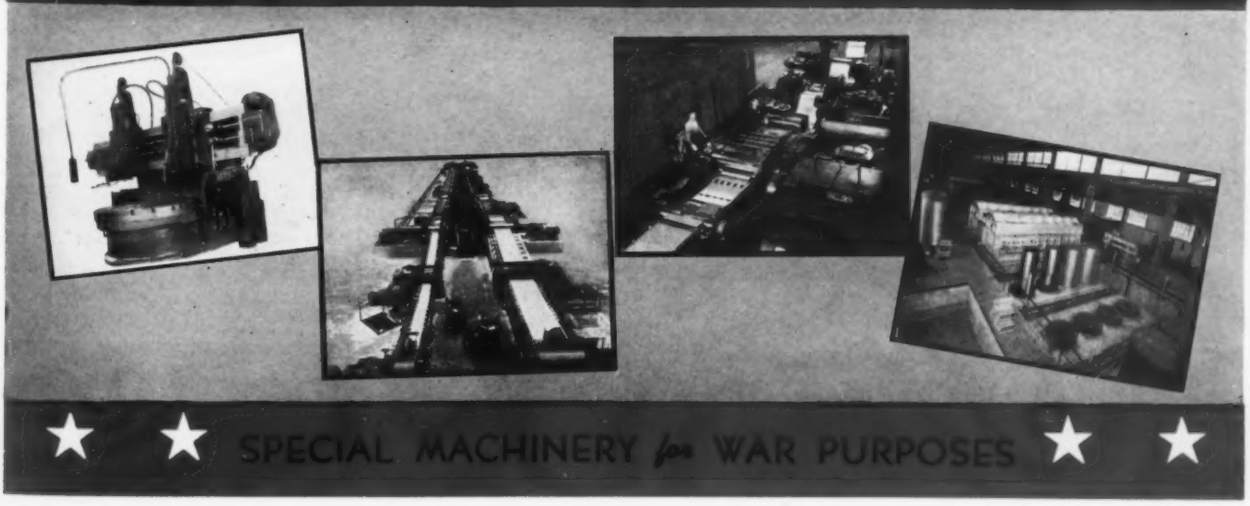
THE HALLDEN MACHINE CO. THOMASTON, CONN.

THE WELLMAN SMITH OWEN ENGR. CORP., LTD. LONDON, ENGLAND

THE WEAN ENGINEERING CO. OF CANADA, LTD. HAMILTON, ONT.

Subsidiary Company

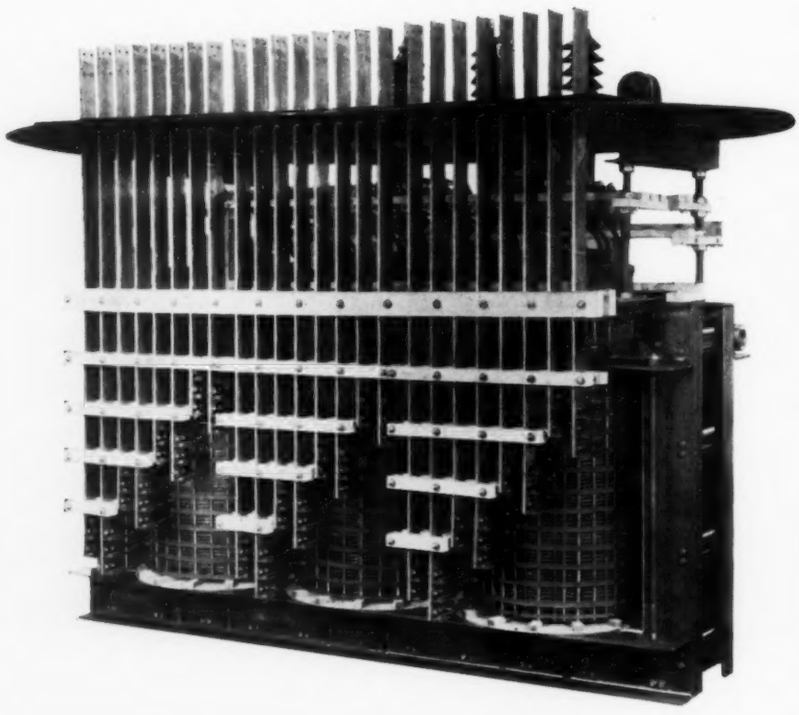
THE BRODEN CONSTRUCTION CO. CLEVELAND, OHIO



★ ★ SPECIAL MACHINERY for WAR PURPOSES ★ ★

FURNACE TRANSFORMER *Facts*

★ The transformer that supplies power to an electric furnace is an extremely complicated unit. The rules governing ordinary designs and construction of Power Transformers do not apply to Furnace Transformers. Many special conditions such as overloads, short circuit stresses, distribution of currents and reduction of eddy losses must be met by engineering skill and highly perfected workmanship.



Pennsylvania Transformer Company has acquired a noted reputation in the Furnace Transformer field. For over thirty years its engineers have closely followed the development of electric furnaces. They fully understand the problems of Electric Furnaces and their relation to Furnace Transformers.

1. OVERLOADS & SHORT CIRCUIT STRESSES

Electric Furnace operation inherently subjects Furnace Transformers to frequent short circuits and heavy overloads. The effect of this on the transformer is complicated by the wide range of voltages which necessitates cutting out large portions of the primary windings. The effects of both the radial and axial short circuit forces are greatly reduced in Pennsylvania Furnace Transformers by the use of Circular Coils and an ingenious winding arrangement.

•

2. BALANCING OF STRESSES

Pennsylvania coils are balanced to reduce the radial and axial short circuit stresses to a minimum. 1. The circular shape protects the coils against deformation due to radial short circuit forces. 2. The total axial short circuit force is calculated for each design and the coils are subjected to an equivalent pressure in a three hundred ton hydraulic press. The ability of the coils to maintain their shape, under the prescribed pressure, guarantees that the transformer will safely withstand short circuits.

•

3. DISTRIBUTION OF CURRENTS

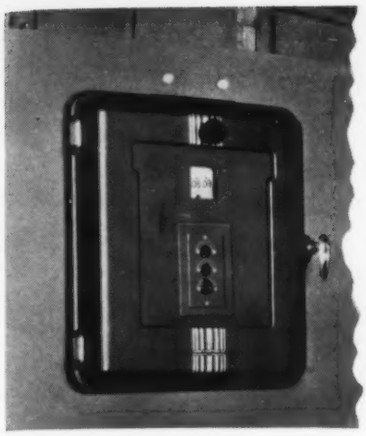
Due to the heavy secondary currents, the winding must be subdivided into numerous parallel sections. A skillful arrangement of the windings insures that each section carries an equal share of the current. Careful transposition of the individual conductors of each section in the windings reduces the copper eddy losses to a minimum. This results in improved efficiency, more uniform copper temperature and prevention of hot spots.

•

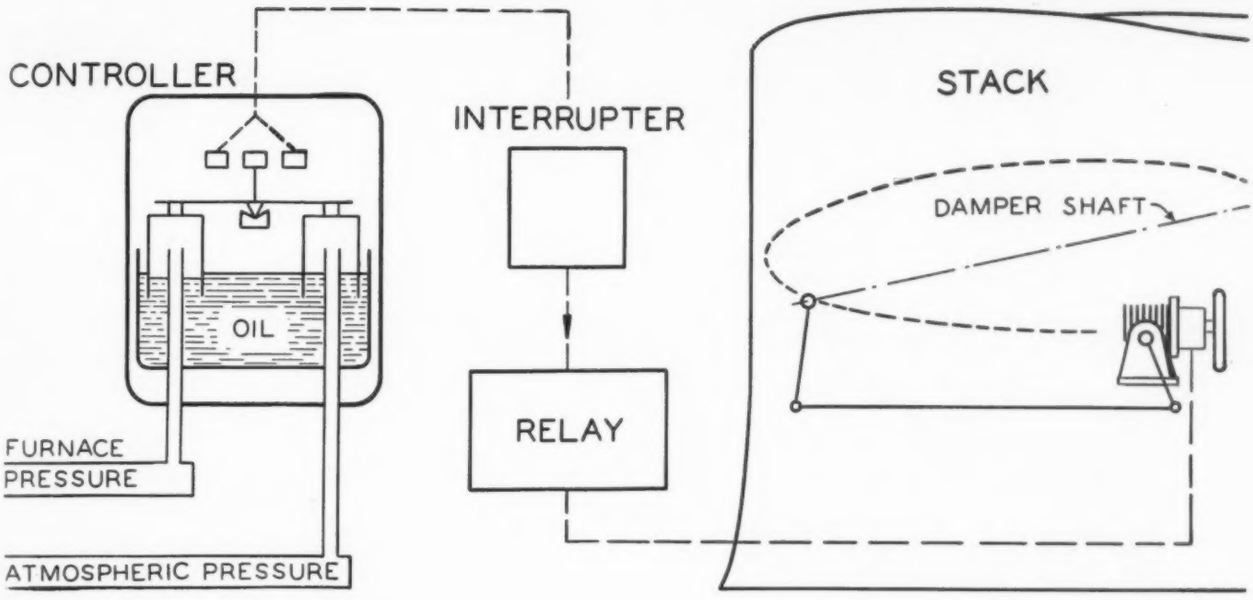
Send your furnace transformer inquiries to Pennsylvania Furnace Transformer Experts.

Pennsylvania
TRANSFORMER COMPANY
PITTSBURGH, PENNSYLVANIA

Pennsylvania TRANSFORMERS



← Set this Controller
And this Drive Unit regulates the damper to carry out your orders →



Here's A "Smoother-Out" For Furnace Pressure

Almost any large, fuel-fired industrial furnace in which pressure is now being controlled by hand can be given much closer control by means of an L&N Furnace Pressure Controller. This equipment sharply reduces uneven pressure as a factor in furnace production; helps hold the flame shape and position, helps stabilize the combustion, and in general increases the furnace's net output.

The Controller handles the furnace just as the helper wishes — it will automatically hold pressure at a predetermined number of thousandths of an inch of water, or will permit manual control, at the helper's discretion. The shift from automatic to manual is made by simply flipping a switch.

No interference with the control of reversal, roof-temperature, etc., is involved in using this Controller. It consists, usually, of two assemblies — a panel with Controller and accessories, and a Drive Unit and linkages for the damper. Installation can be handled by the plant's crew, and maintenance is simple and slight.

The complete equipment is described in Catalog N-01A-600, sent on request. If you have a wartime problem, outline it and we'll promptly send more specific information.

Used in Many Plants

The equipment shown above is installed in a steel mill, and the Drive Unit employed is one of our larger sizes, because of the size and weight of the stack damper. A complete range of units enables the user to select the correct one for any torque from 25 lb ft up to 1000 lb ft, as the case may require. Open-hearth furnaces, soaking pits, slab and cake furnaces, cement and other rotary kilns are among the units in scores of plants which are using L&N Furnace Pressure Controllers with excellent results.

Jrl Ad N-01A-600(1)

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Our nation's plans for victory call for steel and more steel—
SPEED PRODUCTION WITH PITTSBURGH ROLLS

PITTSBURGH ROLLS

PITTSBURGH ROLLS DIVISION of
BLAW-KNOX CO.—"Steel's Partner" • PITTSBURGH, PA.

As 1943 proceeds with encouraging reports on the progress of our armed forces on the global battlefields, we in industry must beware of over-confidence and false optimism. We must work on with unrelenting vigor to keep war materials flowing from our plants in even greater volume. We can ignore no opportunity to improve our product and increase our production. It is with this in mind that I wish to invite the engineering and operating men of the iron and steel industry to take part in the annual meeting and engineering conference of the Association of Iron and Steel Engineers.

J. E. Flynn

President

PROGRAM

Annual Meeting and Engineering Conference

ASSOCIATION OF IRON AND STEEL ENGINEERS

WILLIAM PENN HOTEL - PITTSBURGH, PA.

SEPTEMBER - 28 - 29 - 30

Tuesday, September 28

9:00 A.M. — REGISTRATION — Silver Room.

Chairman:
J. S. MURRAY
Chief Electrical Engineer
Follansbee Steel Corporation
Follansbee, West Virginia

Vice-Chairman:
H. W. NEBLETT
Special Engineer
Inland Steel Company
East Chicago, Indiana

9:15 A.M. — BUSINESS SESSION — Urban Room.

Chairman:
F. E. FLYNN
District Manager
Republic Steel Corporation
Warren, Ohio

Vice-Chairman:
F. H. DYKE
Superintendent, Blooming, Bar and Hot Strip Mills
Wheeling Steel Corporation
Steubenville, Ohio

9:30 A.M. — ELECTRICAL DIVISION — Urban Room.

Chairman:
H. R. FORD
Electrical Engineer
Wheeling Steel Corporation
Steubenville, Ohio

Vice-Chairman:
R. W. GRAHAM
Assistant Electrical Superintendent
Bethlehem Steel Company
Lackawanna, New York

"Fire Protection in Steel Plants," by C. A. Getz, Director of Research, Cardox Corporation, Chicago, Illinois.

"Robots vs the Manpower Situation," by F. Mohler, Engineer, Steel Mill Section, General Electric Company, Schenectady, New York.

"Relay Protection of Distribution Lines," by L. L. Fountain, Switchgear Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

1:30 P.M. — MECHANICAL AND WELDING DIVISION — Cardinal Room.

Chairman:
F. E. KLING
Assistant Chief Engineer
Carnegie-Illinois Steel Corporation
Pittsburgh, Pennsylvania

Vice-Chairman:
STANLEYGRAND-GIRARD
Electrical and Mechanical Superintendent
Sharon Steel Corporation
Sharon, Pennsylvania

"Plant Distribution Systems for Oxygen and Acetylene," by Herman Ullmer, Manager, Process Service, Linde Air Products Company, New York, New York.

"Chain and Chain Repairs," by F. W. Shaw, Columbus-McKinnon Chain Company, Tonowanda, New York.

"Prevention of Corrosion in Water Systems," by H. M. Olson, Ohio Salt Company, Pittsburgh, Pennsylvania.

1:30 P.M. — OPERATING PRACTICE DIVISION — Urban Room.

Chairman:
A. S. GLOSSBRENNER
General Superintendent
Youngstown District
Youngstown Sheet and Tube Company
Youngstown, Ohio

Vice-Chairman:
A. D. BRODIE
Superintendent, 93 In. Cold Strip Mill
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

"Industrial Engineering in War Production," by C. P. Spangler, Industrial Engineer, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

"Electrolytic Tinning Operations," by H. P. Munger, Metallurgist, Republic Steel Corporation, Warren, Ohio.

"Steel for Cartridge Cases," by Lt. R. E. L. Stanford, Ordnance Department, United States Army, Cincinnati, Ohio.

8:00 P.M. — Motion Pictures, selected subjects — Urban Room.

Wednesday, September 29

9:00 A.M. — ROLLING MILL DIVISION — Urban Room.

Chairman:
H. G. R. BENNETT
Engineer, Hot Rolling Mills
Carnegie-Illinois Steel Corporation
Pittsburgh, Pennsylvania

Vice-Chairman:
JOHN A. SCHOLL
Chief Roll Designer
Tennessee Coal, Iron and Railroad Company
Fairfield, Alabama

"Blooming and Billet Mills and Their Rolls," by F. C. T. Daniels and D. L. Eynon, Mackintosh-Hemphill Company, Pittsburgh, Pennsylvania.

"Some Developments in Plate Mills," by W. A. White, Superintendent of Mills, Kaiser Company, Inc., Fontana, California.

"Bar Mill Arrangement and Pass Design," by R. E. Beynon, Superintendent of Roll Shop Department, Carnegie-Illinois Steel Corporation, South Chicago, Illinois.

9:00 A.M. — COMBUSTION DIVISION — Cardinal Room.

Chairman:
E. C. McDONALD
Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

Vice-Chairman:
C. J. WYROUGH
Superintendent, Steam Efficiency and Combustion Department
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

"Fuel Oil Systems," by F. C. Frye, Steam and Fuel Engineer, Great Lakes Steel Corporation, Ecorse, Michigan.

"Pitch as an Open Hearth Fuel," by J. F. Wilbur, Superintendent, Fuel and Combustion, Bethlehem Steel Company, Johnstown, Pennsylvania.

Round Table Discussion — Burning the Lighter Oils in the Open Hearth.

1:30 P.M. — ELECTRICAL DIVISION — Urban Room.

Chairman:
J. H. MILLER
Electrical Superintendent
Internation Harvester Company
Wisconsin Steel Works
Chicago, Illinois

Vice-Chairman:
G. A. KAUFMAN
Chief Electrical Engineer
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

"A New Method of Speed Control and Braking for A-c Cranes," by E. J. Posselt, Engineer, Cutler-Hammer, Inc., Milwaukee, Wisconsin.

"A-c and D-c Drives for Draw Benches and Wire Blocks," by R. A. Geuder, Manager, Metal Industry Applications, Reliance Electric and Engineering Company, Cleveland, Ohio.

"Electrical Equipment for Modern Arc Furnaces," by C. C. Levy, Industry Engineering Metal Working Section, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

1:30 P.M. — OPERATING PRACTICE DIVISION — Cardinal Room.

Chairman:
A. C. CUMMINS
General Superintendent
Carnegie-Illinois Steel Corporation
Youngstown, Ohio

Vice-Chairman:
C. P. BETZ
Assistant Manager, Hanna Furnace Division
Great Lakes Steel Corporation
Ecorse, Michigan

"Gas Yield and Economy in the Coke Plant," by R. W. Campbell, Superintendent, By-product Department, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

"Modern Trends in Blast Furnace Design," by Frank Janecek, Blast Furnace Engineer, Republic Steel Corporation, Cleveland, Ohio.

"Variations in Blowing Rates for Blast Furnaces," by E. L. Clair, Vice President, Interlake Iron Corporation, Chicago, Illinois.

"Bedding and Reclaiming Metallurgical Raw Materials," by A. J. Boynton, A. J. Boynton and Company, Chicago, Illinois.

7:00 P.M. — INFORMAL STAG DINNER — Ball Room.

Speakers: W. Sykes, President, Inland Steel Company, Chicago, Illinois — "Retrospect and Prospects."
J. T. Whiting, Director, Steel Division, WPB, Washington, D. C. — "Steel After 22 Months of War."

Thursday, September 30

9:00 A.M. — COMBUSTION DIVISION — Urban Room.

Chairman:
P. F. KINYOUN
Combustion Engineer
Bethlehem Steel Company
Lackawanna, New York

Vice-Chairman:
H. C. REESE
Fuel Engineer
Wheeling Steel Corporation
Steubenville, Ohio

"Pulverized Fuel for Heating and Metallurgical Furnaces," by L. S. Wilcoxson, The Babcock and Wilcox Company, New York, New York.

"Colloidal Fuel as a War and Post-War Liquid Fuel," by J. G. Coutant, Fuel Engineer, New York, New York.

"Feed Water Treatment for Weirton's High-Pressure Station," by J. H. Strassburger, Manager, Maintenance and Service, Weirton Steel Company, Weirton, West Virginia.

9:00 A.M. — LUBRICATION DIVISION — Cardinal Room.

Chairman:
P. J. DOYLE
Lubrication Engineer
Republic Steel Corporation
Cleveland, Ohio

Vice-Chairman:
C. E. S. EDDIE
Plant Lubrication Engineer
Great Lakes Steel Corporation
Ecorse, Michigan

"Centralized Lubrication for Blast Furnaces," by A. J. Jennings, General Sales Manager, Farval Corporation, Cleveland, Ohio.

"Lubrication of Non-Metallic Bearings," by G. E. Reiser, Assistant Lubrication Engineer, Bethlehem Steel Company, Lackawanna, New York.

Round Table Discussion — Lubrication Practices.

12:00 — SAFETY LUNCHEON — Ball Room.

Speaker: W. A. Irvin, Director, United States Steel Corporation, and Chairman of the Board of Trustees, National Safety Council, New York, New York.

2:00 P.M. — SAFETY DIVISION — Urban Room.

Chairman:
R. H. FERGUSON
Manager of Safety
Republic Steel Corporation
Cleveland, Ohio

Vice-Chairman:
L. R. PALMER
Conservation Engineer
Equitable Life Assurance Society of United States
New York, New York

"Developing a Practical Safety Program," by A. H. Fosdick, Superintendent of Blast Furnaces, Bethlehem Steel Company, Bethlehem, Pennsylvania.

"Building Safety into the Plant," by H. J. Griffith, Manager of Safety and Welfare, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

"The Responsibility for Safety," by W. Dean Keefer, Vice-President, Lumberman Mutual Casualty Company, Chicago, Illinois.

...put forth your utmost efforts to increase production of steel...

PHOTO BY BACHRACH

WAR PRODUCTION BOARD
WASHINGTON, D. C.

July 23, 1943

IN REPLY REFER TO:
Steel Division
Room 1029
Social Security Building

Association of Iron & Steel Engineers
Empire Building
Pittsburgh, Pennsylvania

Gentlemen:

One of the most powerful weapons against the Axis Nations in the war has been the technical knowledge of the steel industry's engineers and plant operators. This weapon has been in constant use since long before Pearl Harbor. Without it we could not win the war.

Among the heaviest contributors to the unmatched pool of engineering knowledge helping to win the war are the members of the Association of Iron and Steel Engineers, which will hold its annual meeting at Pittsburgh in September.

An event such as this coming meeting is significant in the fight to liberate the peoples of Europe because it represents the free exchange between free men of useful ideas on steel production.

This is a mechanized war and still greater quantities of steel are needed. I urge you to put forth your utmost efforts to increase production of steel from existing plants and from the facilities now under construction and nearing completion.

As Director of the Steel Division, charged with the responsibility of seeing that our country has the steel it needs, I extend to you my best wishes for a successful annual conference.

Sincerely yours,

J. T. Whiting

John T. Whiting
Director, Steel Division

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If your business requires materials handling, the operation can be made safer, faster, and more economical by the use of Heppenstall Automatic Safe-T-Tongs. And they work so simply—like this: First you lower them on the object ...allow slack and the tongs unlock ...the tongs grip as they come up ...carry swiftly ...then as the load is placed, the tongs lock open again automatically ...ready for the next job.

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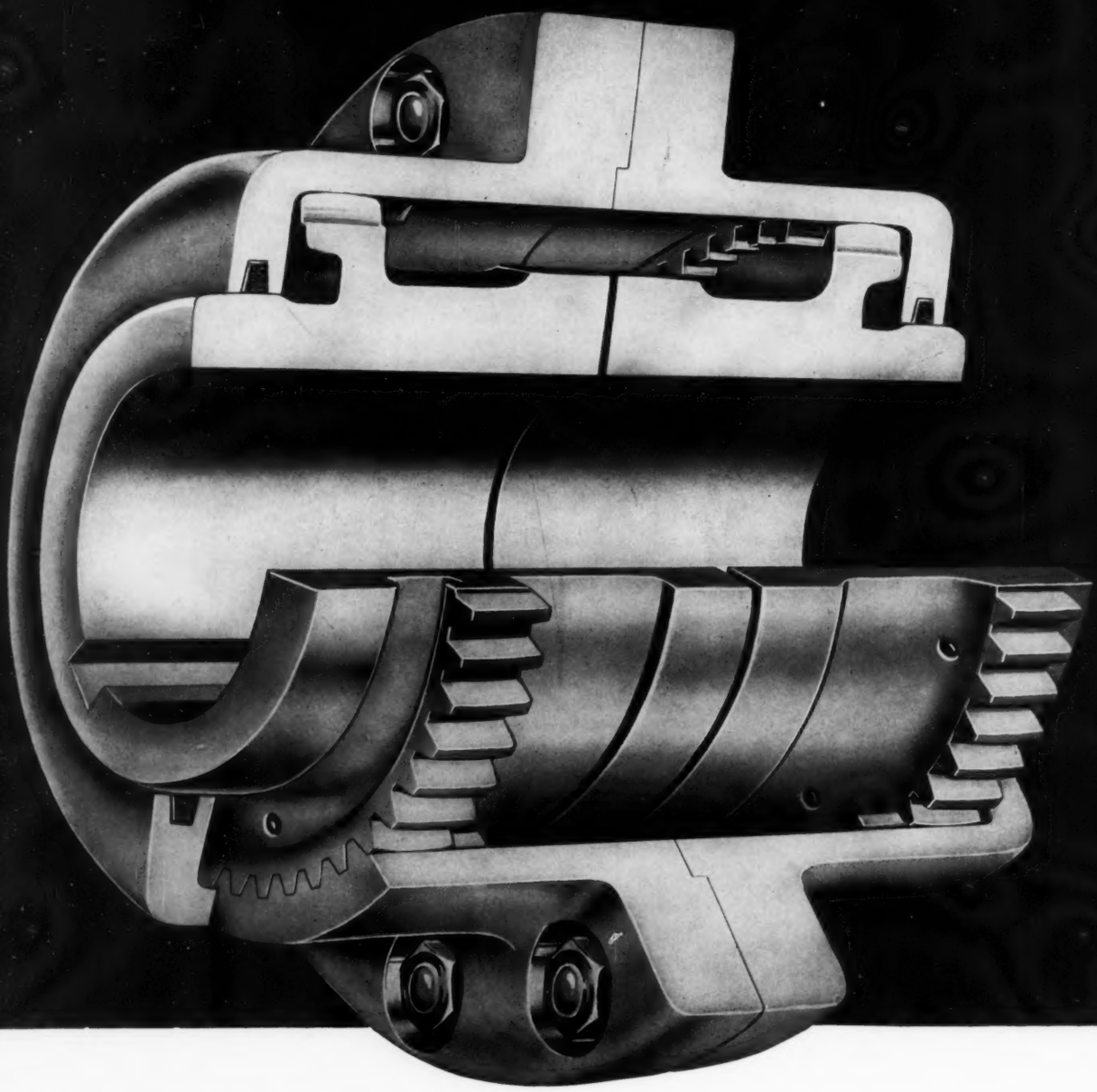
Heppenstall Automatic Safe-T-Tongs

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST

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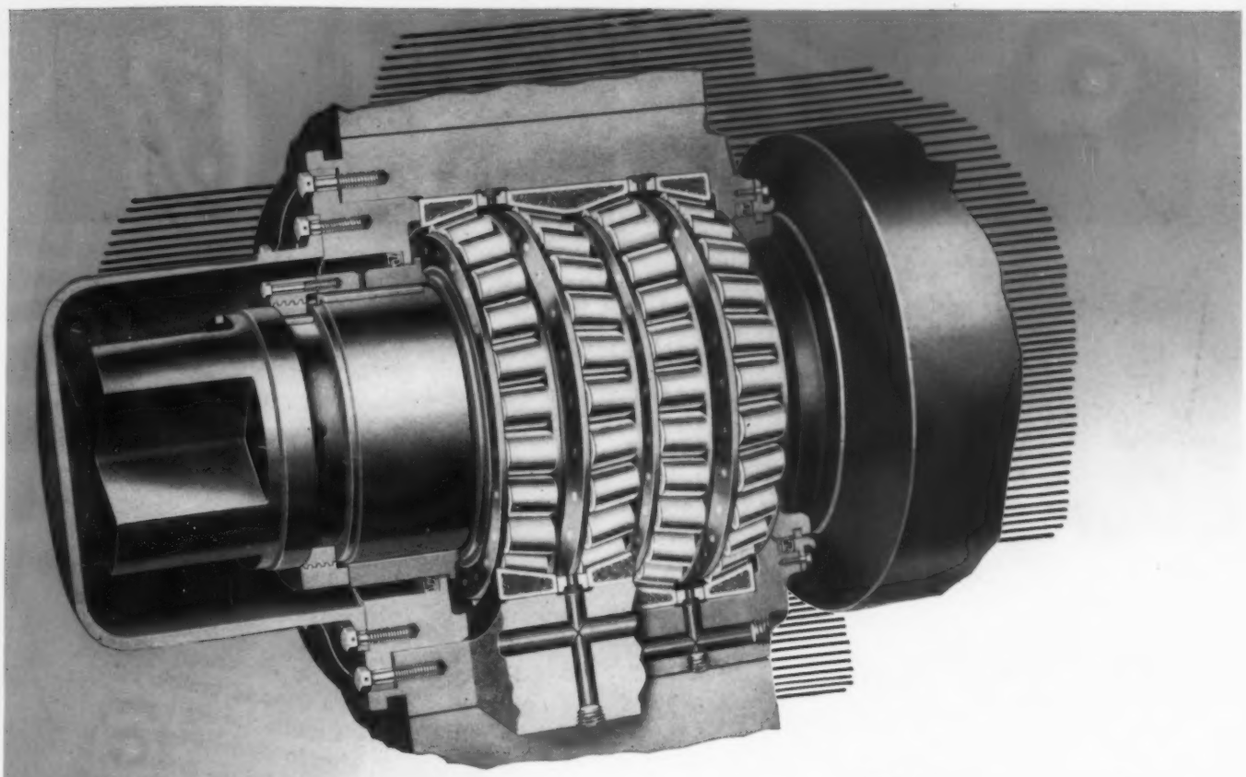

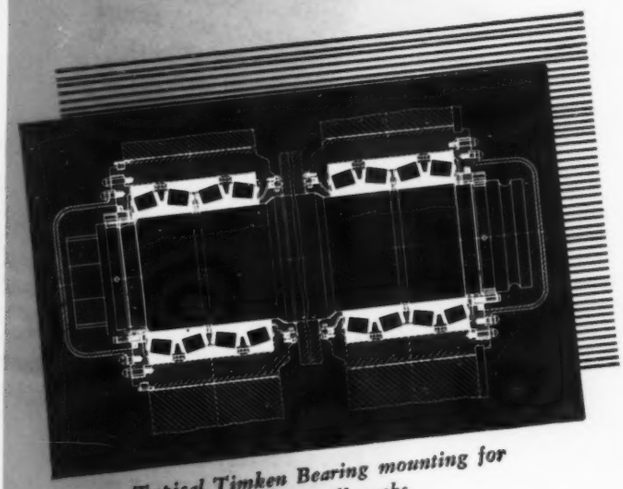

Typical Timken Bearing mounting for back-up roll necks.

Put experience on your mill roll necks with Timken Bearings

There is no short cut to experience—and no substitute for it. This has been demonstrated time after time in the application of roller bearings on steel mill roll necks.

As a result of our many years of experience in the design and manufacture of roller bearings for roll neck service we long ago eliminated all guesswork and cut-and-try methods.

Thus we know in advance what can be expected of any Timken Roll Neck Bearing installation — in high tonnage rolled; in low bearing cost per ton rolled; in power saving; and maintenance reduction. Why experiment? The Timken Roller Bearing Company, Canton, Ohio.

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TRADE-MARK REG. U. S. PAT. OFF.

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*CARBON

TIDEWATER LUBRICANIA

DEFINITION: The Carbon Residue Test is a means of determining the amount of Carbon which remains after an oil has been evaporated under certain conditions of high temperature and under exclusion of air.

TEST (Conradson Carbon Residue): Following a carefully prescribed procedure with standardized equipment, a sample of the oil is heated and the oil vapors allowed to burn. After the vapors cease to come off the heat is raised for a given period to cause the destructive distillation of the remaining liquid. The Carbon Residue is the weight of the carbonaceous residue left in the crucible, expressed in percentage of the original weight of the oil.

EXAMPLES:

(% Carbon Residue)	
Nil	Gasoline
Nil	Kerosene
Trace — 0.05	No. 2 Fuel Oil
0.03-0.25	Machine Oils
0.3-1.5	SAE 50 Motor Oil
1.5-4.5	Steam Cyl. Oils

SIGNIFICANCE: The Carbon Residue Test may be important with fuel oils or gas oils used in certain oil burning or gas manufacturing equipment. As an index to carbon forming tendencies of lubricating oils for use in internal combustion engines, it is totally unreliable. The quantity and nature of such engine deposits are greatly influenced by the oxidation susceptibilities of the oil and other factors peculiar to engine operation. Oils high in resistance to oxidation and otherwise most desirable for heavy duty operation often give relatively high Carbon Residue values.

DRUMS! DRUMS! DRUMS!
War needs make it extremely important that all empty drums be returned immediately.

To assure the unvarying high quality of Tycol Products they are rigidly controlled and subjected to all essential tests during manufacture. Tycol lubricants for internal combustion engines are available in different types and grades to meet different conditions of operation. Call upon the Tide Water industrial engineers who will recommend the Tycol product best suited to your problem.

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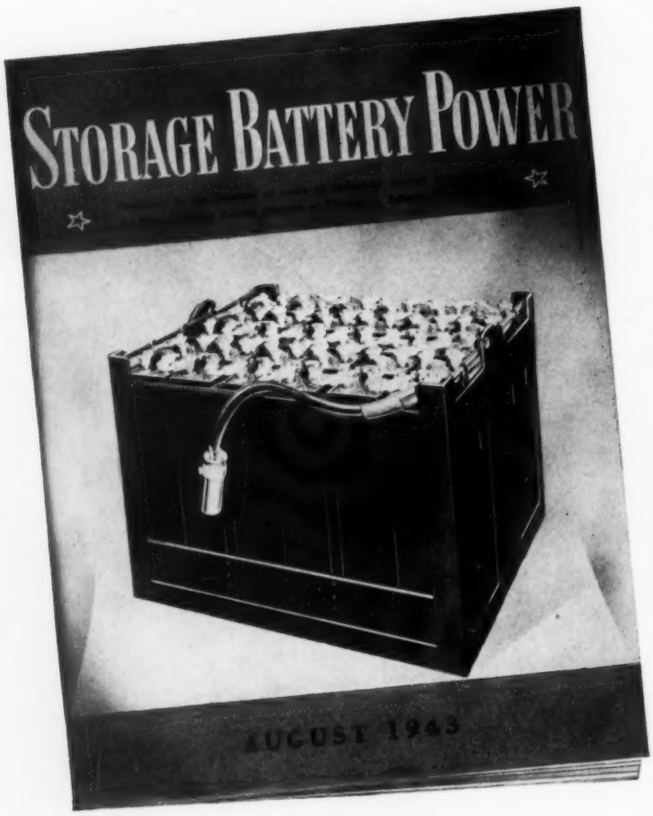
RESIDUE

*This is #4 of a series of informative messages concerning the meaning and significance of commonly used tests and terms employed to describe the characteristics of lubricating oils.

INDUSTRIAL LUBRICANTS

How Battery Industrial Trucks Speed Output of Army Tanks



Other features in this issue:

How a manufacturer of heavy machinery increased capacity by adopting a crane-fork-truck method of handling—getting higher utilization of store-room space and supplementing shop crane for handling work in process and in erection department . . . How a shovel scoop truck handles loose material in bulk . . . How to lay out a charging station . . . Send for your copy of the August issue of "Storage Battery Power."

Edison
ALKALINE BATTERIES

Ingenious Coordination with Assembly Lines Reported in "Storage Battery Power"

In one of the nation's great tank assembly plants battery industrial trucks in the assembly line extend material handling beyond the physical and economic limits of the overhead cranes and feed parts to the line in a variety of operations unique in material handling.

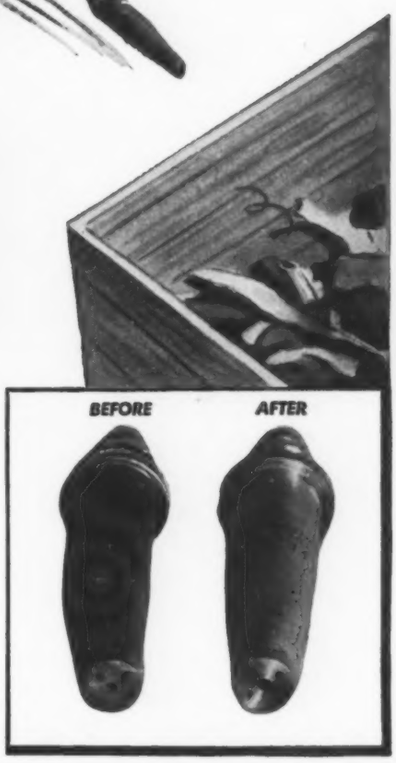
While the application of the truck fleet greatly augments the flexibility of the assembly craneway, the truck fleet itself achieves maximum flexibility through the interchangeability of its units. The predominant unit is the platform lift truck which, through ingenuity of application, has acquired further versatility.

The plan of material handling, which is reported in the August issue of "Storage Battery Power," is remarkable for (1) the many kinds of handling jobs that are being done by the same kind of handling equipment, and (2) the large number of jobs that are being done by more than one kind of equipment.

For a copy of the August issue of "Storage Battery Power," address Edison Storage Battery Division, Thomas A. Edison, Inc., West Orange, N. J.

DON'T SCRAP that AIRCO Tip!

Let an Airco Repair Station recondition it for you



Here's a typical result of Airco Repair. The tip at left—battered, nicked, and choked with carbon—was made good as new by skillful repairs.

Copper is one of the most critical materials. It must be conserved.

Here is one way to do it – don't discard a worn Airco welding or cutting tip until you've made certain it cannot be reclaimed. Send all your damaged Airco tips to us. Our skilled repair men will inspect them thoroughly and put them back into first-class working order . . . unless they're beyond repair.

In this way Airco can help you reclaim many tips that would otherwise end up in the scrap-box. So see that all old Airco tips are collected now and forward them to the nearest Air Reduction office.

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IN TEXAS: MAGNOLIA-AIRCO GAS PRODUCTS CO.

General Offices: HOUSTON, TEXAS

AIRCO WILSON

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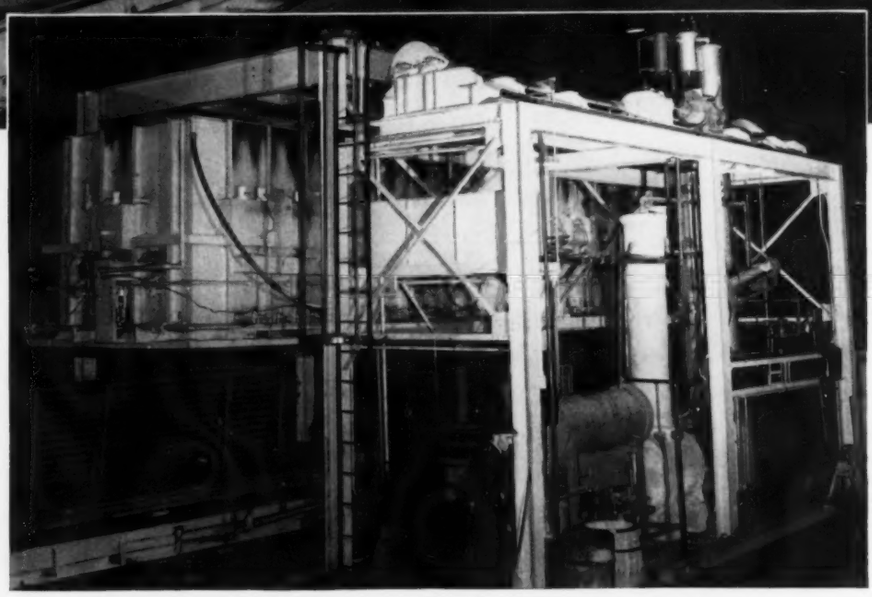
THIS equipment at the Spang Chalfant Division, of The National Supply Company, Ambridge, Pa., is used exclusively for spheroidizing No. 52100 seamless steel tubing in a nitrogen atmosphere.



Nitrogen Gas Atmosphere Generating Equipment

The Wilson Annealing Unit is covered by Patents Nos. 1,952,402, 2,068,477, 2,078,356, 2,081,612, 2,089,843, and other patents pending.

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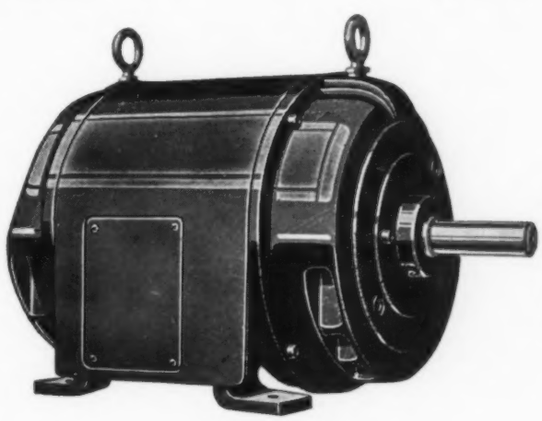

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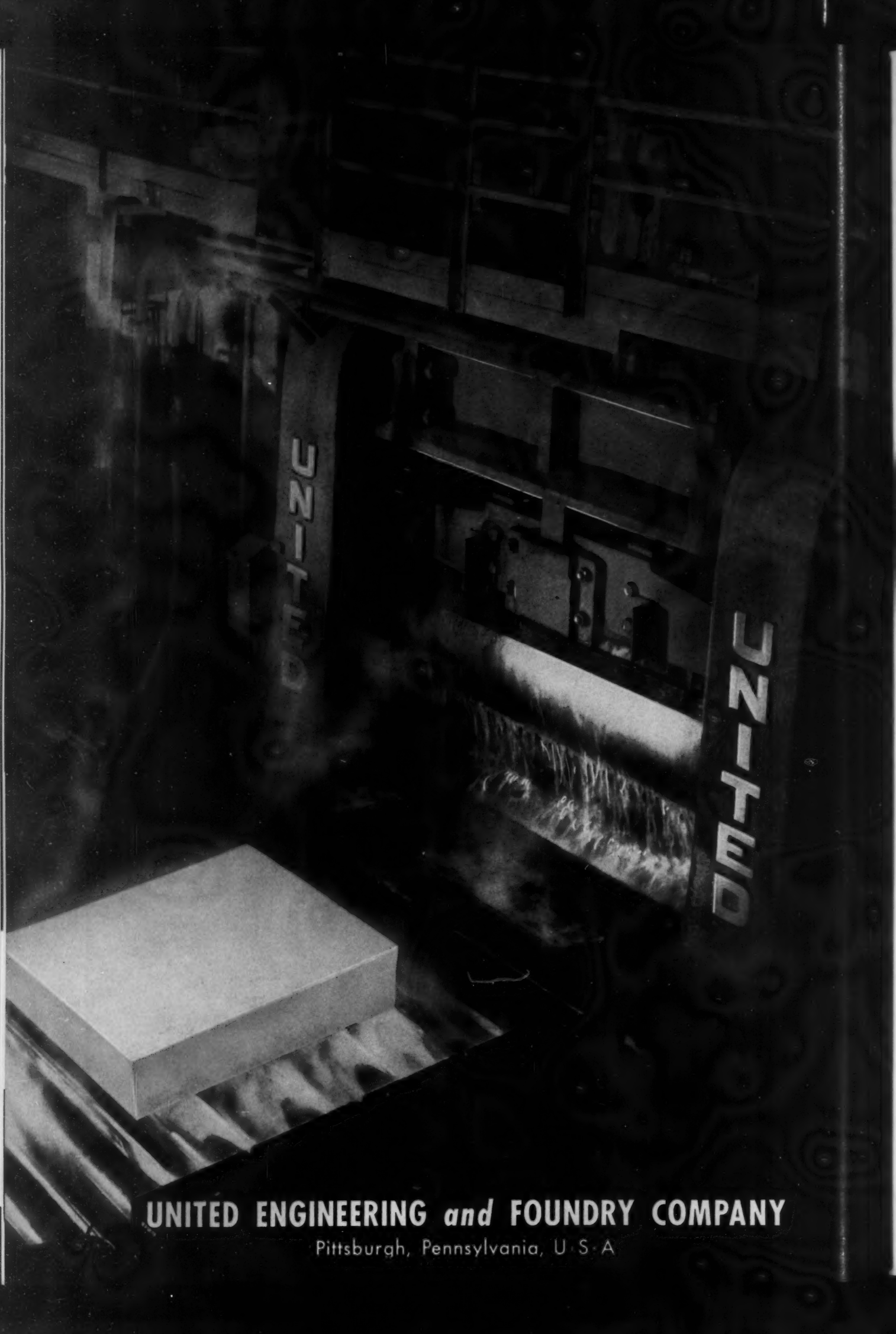

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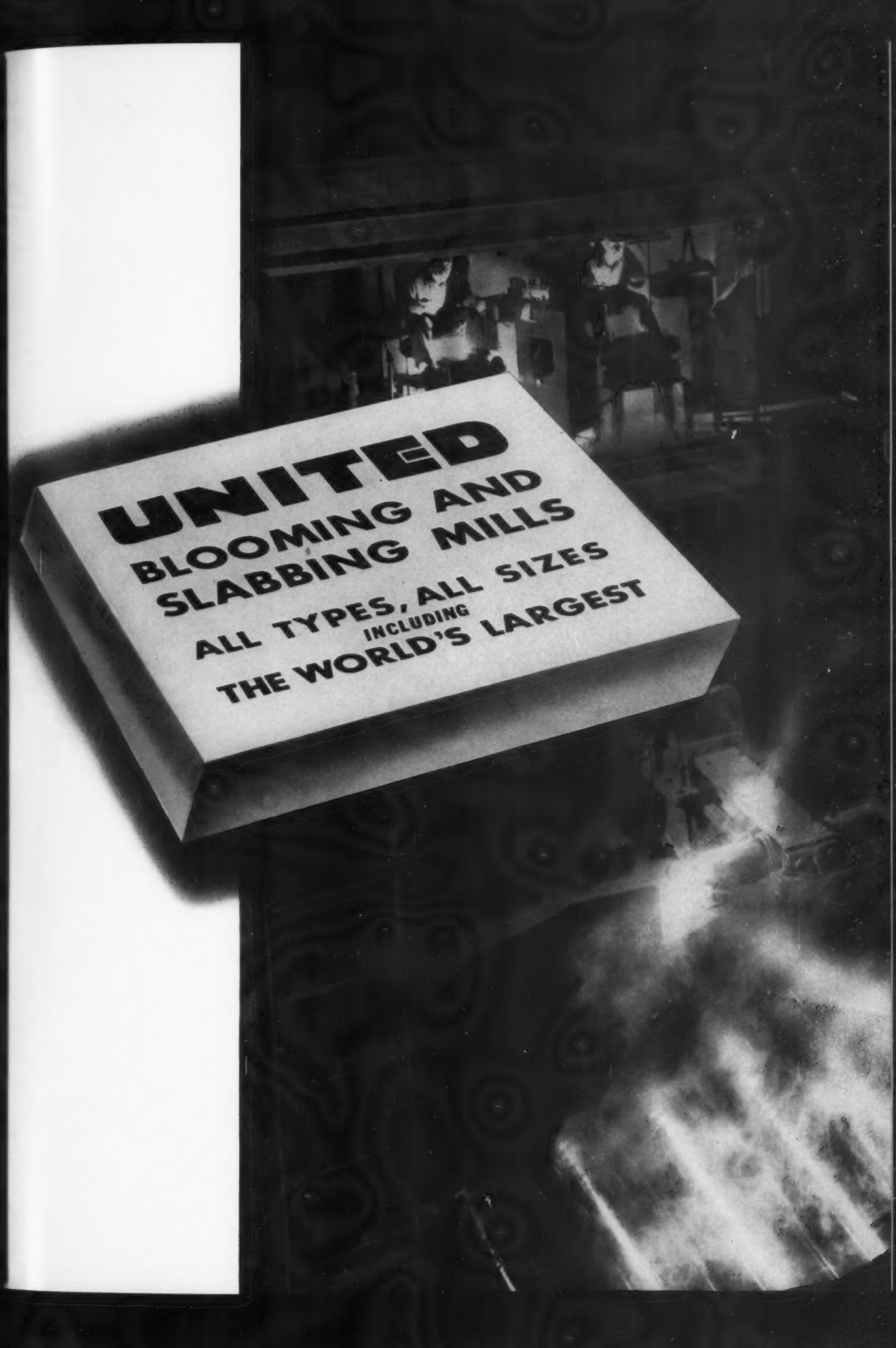
Pittsburgh, Pennsylvania, U·S·A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BLOOMING AND
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ALL TYPES, ALL SIZES
INCLUDING
THE WORLD'S LARGEST

Common Carriers

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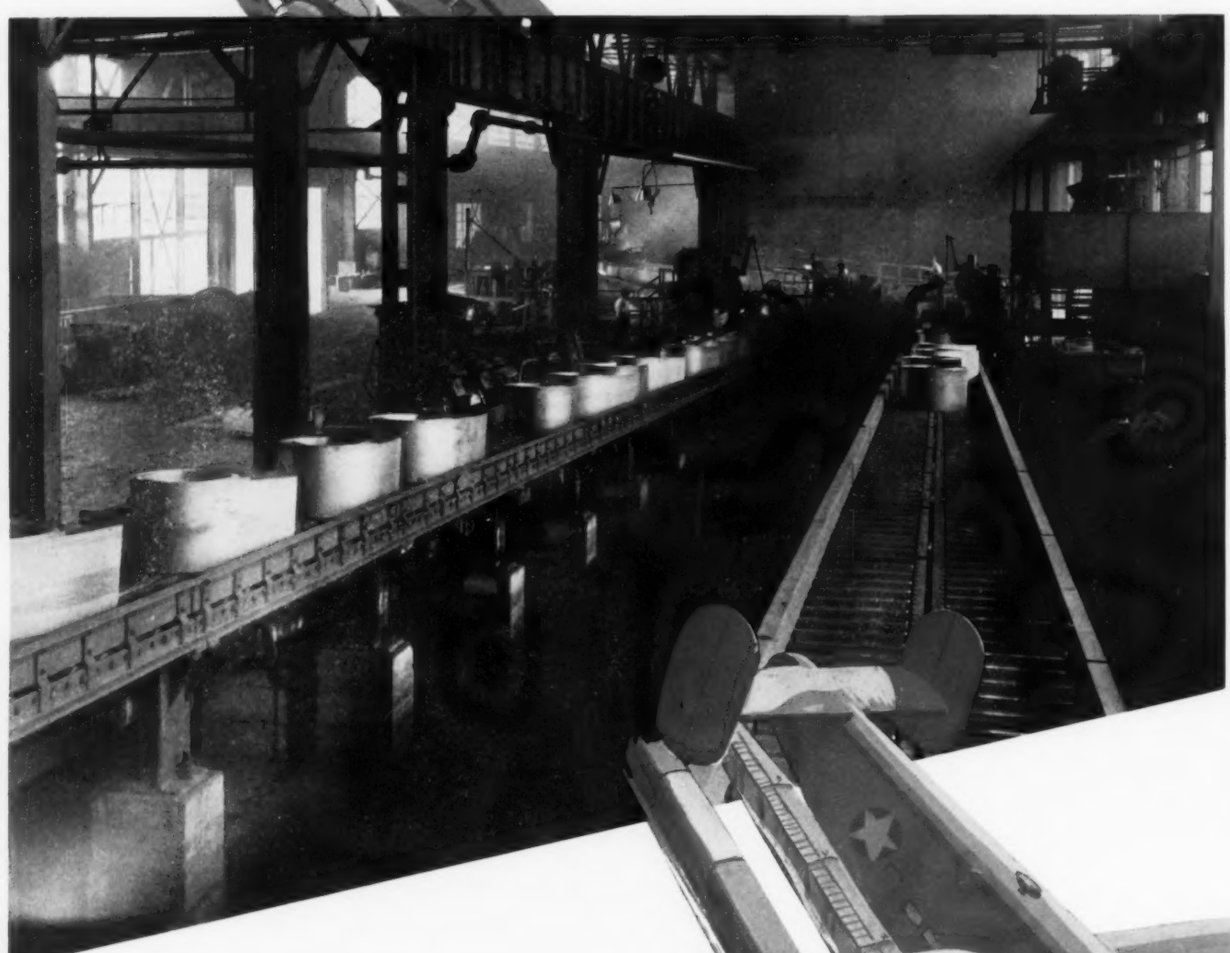

SPEEDY, ON-TIME TRANSPORTATION of materials, supplies and parts within a plant ranks in importance to the war effort with America's railways, trucks, ships and cargo planes.

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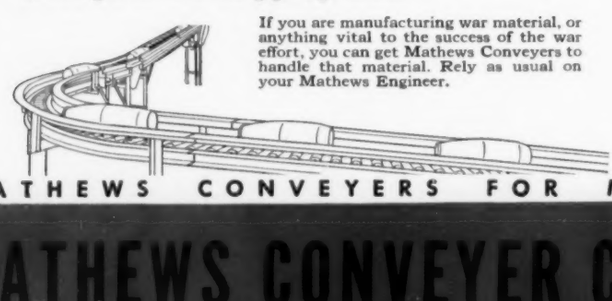

If you are manufacturing war material, or anything vital to the success of the war effort, you can get Mathews Conveyers to handle that material. Rely as usual on your Mathews Engineer.

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Empire Building
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**United States Army*

IRON AND STEEL ENGINEER

AUGUST • 1943
VOL. XX NO. VIII

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Published Monthly by

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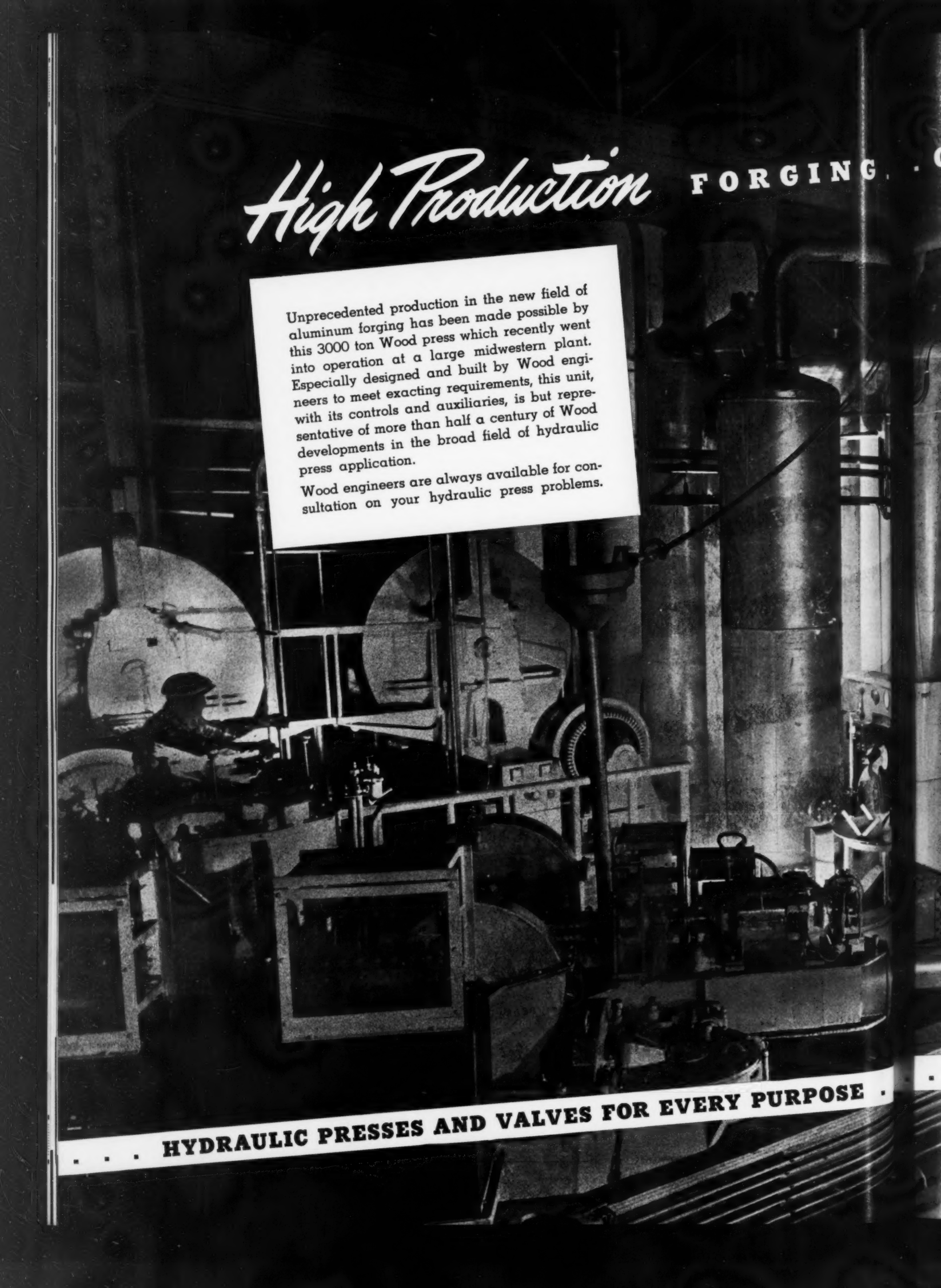
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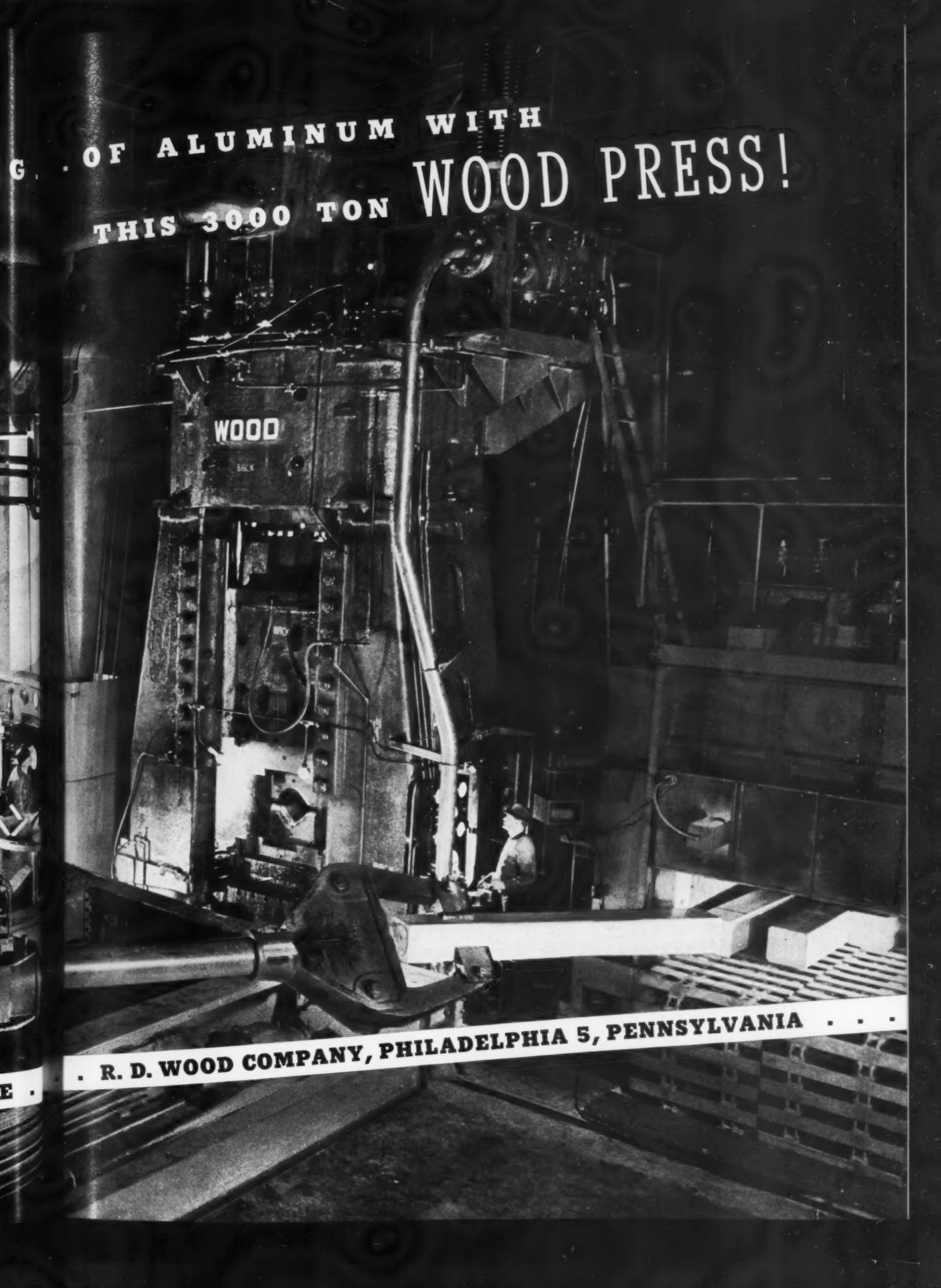
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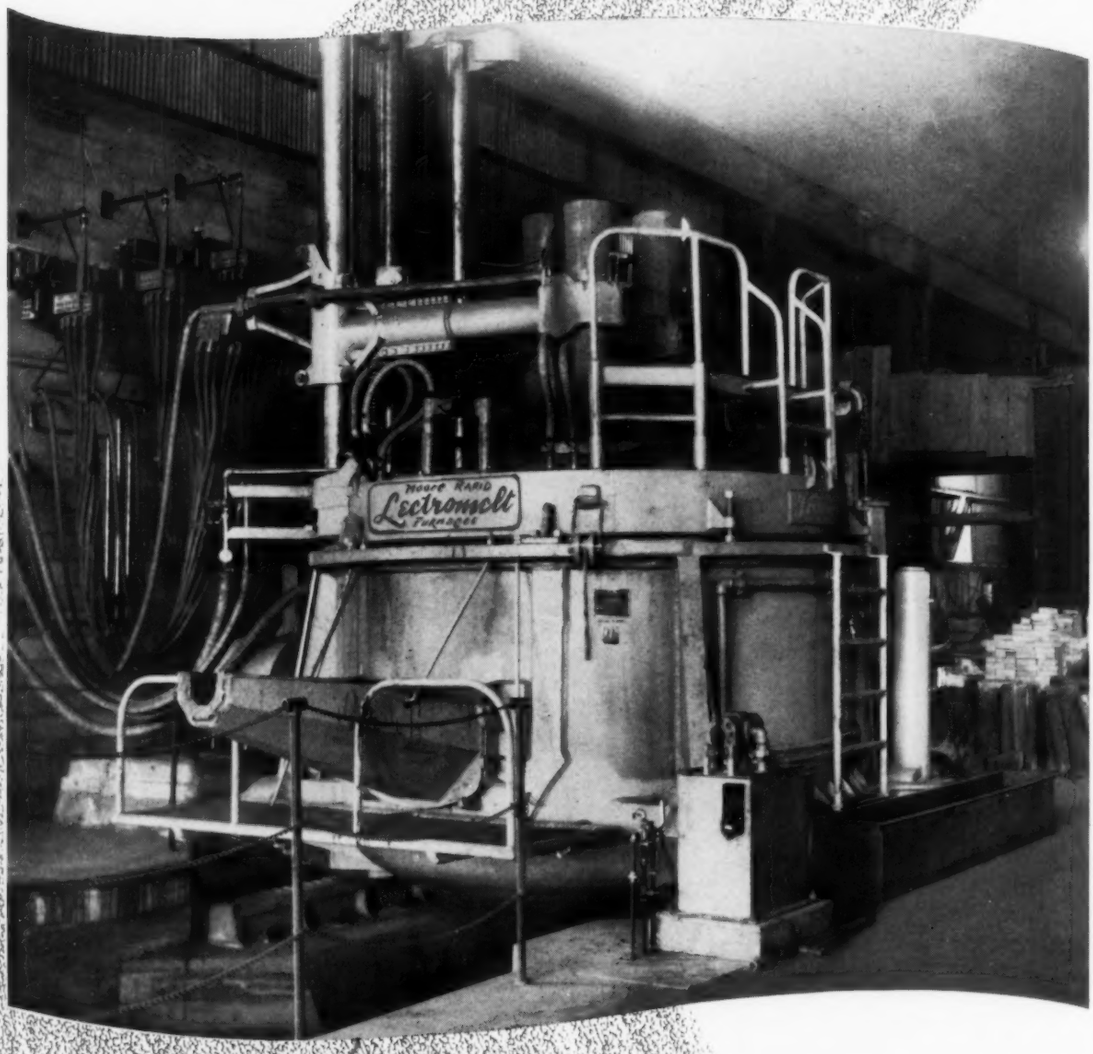

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Palm Oil CONTROL FOR Cold Mills

. . . . the procurement of palm oil has been materially affected by the war, making any decrease in consumption highly desirable . . . . savings of 70-75 per cent were made by the system described by Mr. Duffy . . . .

by C. E. Duffy, ASSISTANT FUEL ENGINEER

BETHLEHEM STEEL COMPANY

SPARROWS POINT, MARYLAND

▲ THE use of palm oil in cold rolling is long established. Due to its high surface tension palm oil is perhaps better suited for this work than any other commercial product known.

Palm oil is native to West Africa and the East Indies. It has been produced in abundant quantities and was relatively cheap as long as imports could be easily continued.

Soon after the start of the present war it became evident that this abundant supply would be materially decreased. Hence a study of the use of palm oil in our cold strip mills at Sparrows Point was started in 1940.

The palm oil system then installed on our mills consisted of orifices and hand operated valves which were very difficult to regulate. To prevent any possibility of the strip running dry, due to stopped-up valves or orifices, more oil than necessary was used. The palm oil consumption for 1939 was approximately 12 lb per ton of strip rolled.

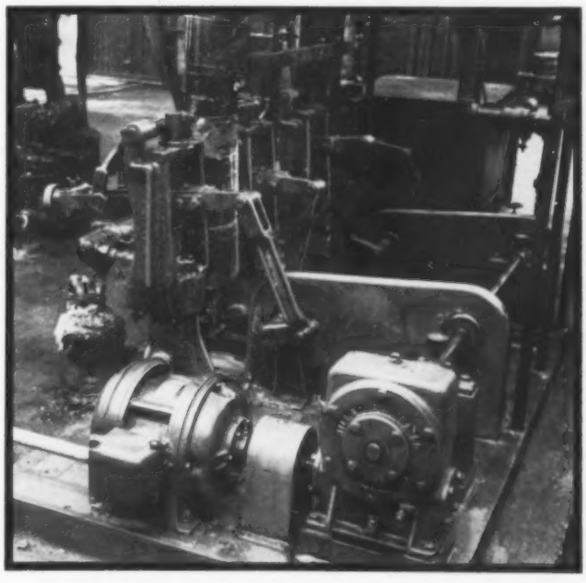
A temporary system for delivering palm oil mixed with water was installed on our No. 2 tandem mill in April, 1940. The equipment consisted of a tank, motor driven circulator, motor driven agitator, steam heating coil with temperature control, integrating meters and a motor driven recirculating pump. The pipe lines, valves, and orifices on the mill were not changed. This system, operated on 50 per cent palm oil and 50 per cent water, resulted in a marked improvement in the palm oil consumption.

The mixture was applied to our No. 1 mill in June, 1940, by the addition of another motor driven recirculating pump. Because of the long lines, the oil and water had a tendency to separate, causing erratic feeding of palm oil in this mill. On some orders, the mixture had to be discontinued and straight palm oil used.

This temporary equipment was made up of surplus plant material. Although it served to prove the value of a mixture of palm oil and water, it had many mechanical defects, and could not be expected to operate long because of the palmetic acid corrosion of plain steel parts.

The installation of our present system was started in

Figure 1 — This four-feed proportioning pump unit maintains the exact desired ratio of water to oil.



Presented before A. I. S. E. Philadelphia District Section Meeting, March 6, 1943.

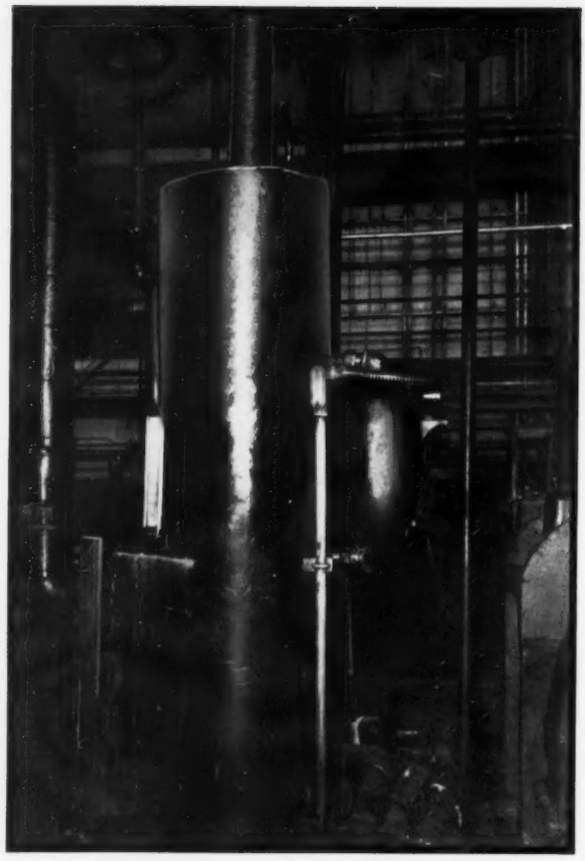
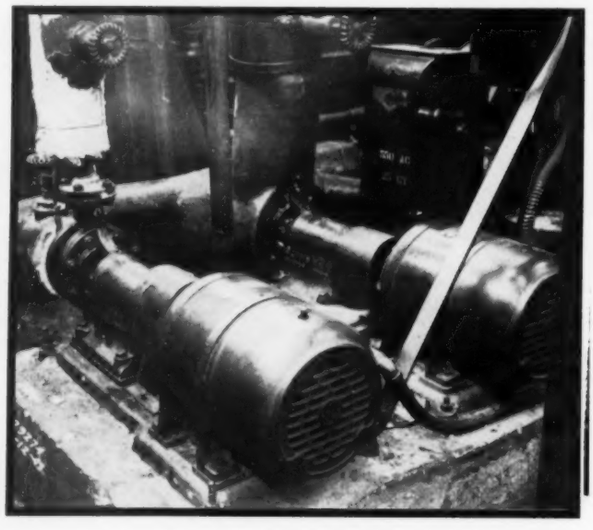


Figure 2 — (above) A float switch in this small reservoir tank starts and stops the proportioning pump unit.

Figure 3 — (below) Two 40 gpm pumps are installed for recirculating the oil-water mixture from the reservoir tank to the mill.

Figure 4 — (right) Variable speed feeder pump units deliver the oil-water mixture from the recirculating header to the mill.



January, 1941. It consists of three main groups of equipment as follows:

1. *The proportioning group* — This group is composed of a four-feed motor driven proportioning pump unit, Figure 1, having three water feeds and one oil feed, each with a micro screw adjustment, which allows for almost any ratio of water to oil. The pumps are constructed of monel metal. The pump unit operates at a pressure of 50 psi and has a capacity of 58 gallons per hour at 43 strokes per minute. It is driven by a one horse power motor with a 40:1 speed reducer. Meters are provided for measuring the quantity of oil and water used on each turn. Recently a steam heated tank has been installed to provide hot water at approximately 160 F to the pumps. The starting and stopping of the pump unit is governed by a float switch in a steam heated reservoir chamber, Figure 2, which receives the palm oil and water from the proportioning pump. This reservoir chamber is relatively small, having an operating capacity of 40 gallons. The capacity is so small that any mixture changes on the proportioning pumps will be effective in the shortest possible time on the mill.

2. *The recirculating group* — This group is made up of two motor driven 40 gpm turbine type pumps,

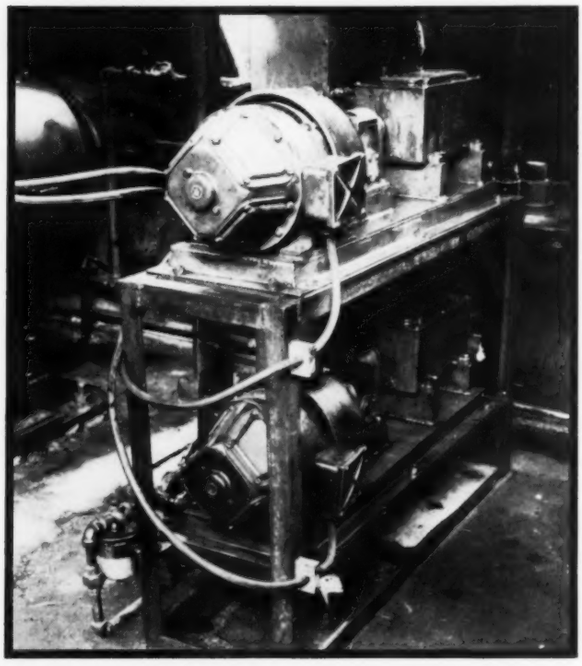


Figure 3. These pumps are equipped with monel metal shafts and impellers and are used for recirculation and for mixing of the palm oil and the water. One pump is maintained as a spare.

The recirculating line is made of 2 in. extra heavy steel pipe and is steam heated. It extends from the recirculating pumps to the mill, then to the regulating feeders and back to the reservoir chamber. The temperature of the mixture is controlled automatically by a self-acting temperature regulator, maintaining the oil-water mixture at 180 F. A relief valve determines the pressure in the header, as well as the amount recircu-

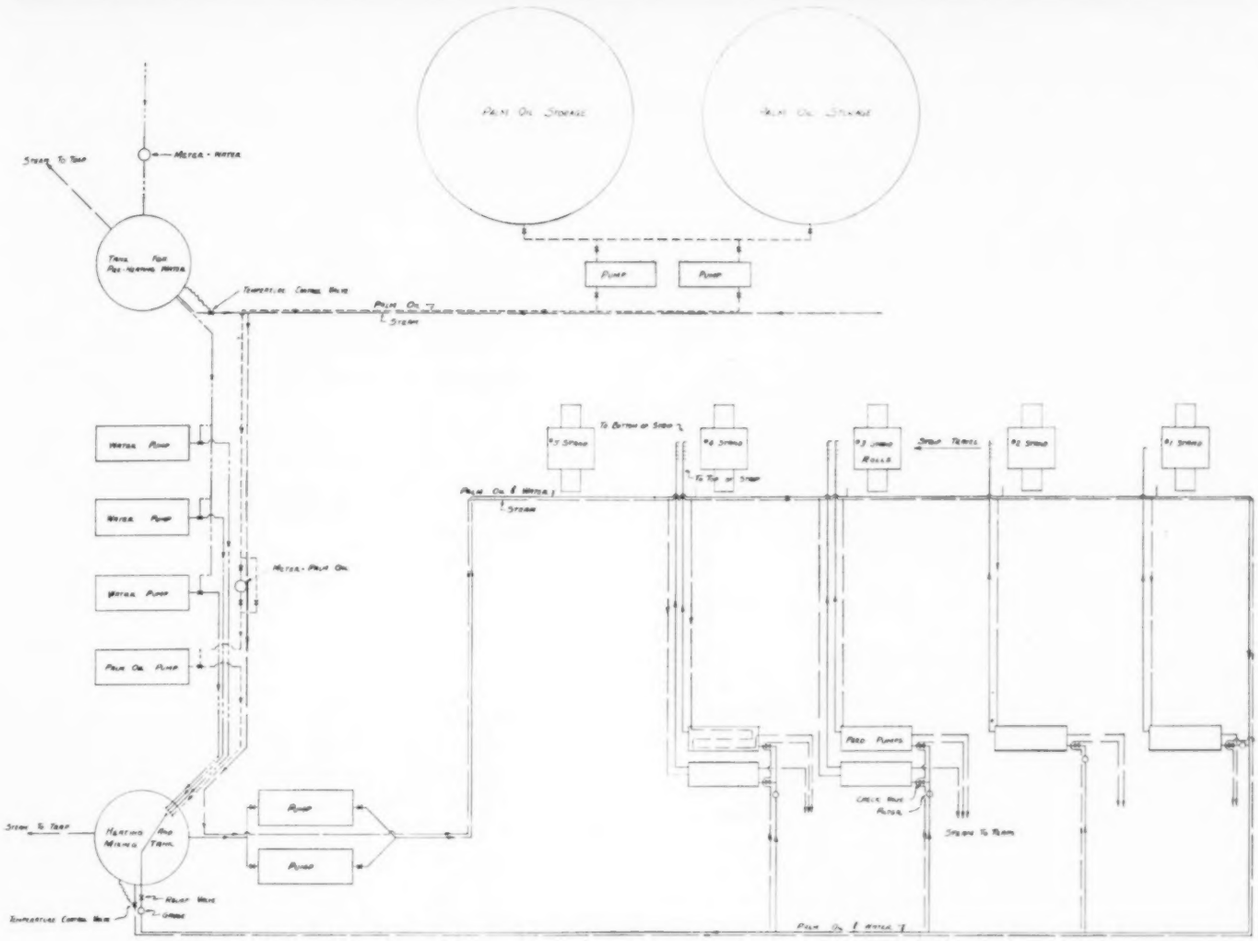


Figure 5 — Flow diagram of palm oil-water mixture system.

lated. The quantity of palm oil-water mixture recirculated is very important. When recirculation is decreased, trouble is at once encountered on the mill, due to separation of oil and water. For this reason, oversized recirculating pumps must be provided.

The recirculating line is installed adjacent to the mills, because during the early development of this control, the regulating feeders were not yet installed. The original feed lines were connected to the recirculating line and used to distribute the mixture to the strip. These feed lines are still available for use whenever the automatic feeders are not operating.

3. *The regulating group* — This group is composed of six motor driven variable speed feeder pump units, Figure 4, made up of five individual pumps. Each pump has a relief valve, which operates when the line from the pump to the mill becomes stopped up. A $\frac{3}{8}$ in. line, wrapped with a steam line, carries the oil-water mixture from the recirculating header to each feeder pump unit. The mixture passes through a filter and a check valve before entering the suction of the individual pumps, and is discharged from the pumps through $\frac{1}{4}$ in. lines to the mill. These lines are wrapped in a bundle with a steam line. All steam lines are trapped. It is quite necessary to keep the mixture lines hot to prevent segregation and possible stoppage. The palm oil-water mixture is fed to the mill as follows:

Strip leaving No. 1 stand	1 feed to top of strip
	4 feeds not used
Strip leaving No. 2 stand	5 feeds to top of strip
Strip leaving No. 3 stand	5 feeds to top of strip
	5 feeds to bottom of strip
Strip leaving No. 4 stand	5 feeds to top of strip
	5 feeds to bottom of strip

The mixture of palm oil and water is fed directly to the top of the strip, while a special roll transmits the mixture to the bottom of the strip by means of a tension roll.

Each feeder pump unit is operated by a $\frac{3}{4}$ hp motor with a 37.5:1 speed reducer. An individual rheostat control provides a capacity range of 0.7 gallons per hour to 22 gallons per hour for each unit. A master control starts and stops all pump units with the starting and stopping of the mill.

The most difficult problem encountered in the use of a mixture of palm oil and water was a satisfactory control of the mixture feed to the strip. The feeder pump units were originally installed on top of the mill stands. This location was chosen because it gave the shortest

TABLE I

Rate of Palm Oil Used, 1939-1942

Month	Pounds of palm oil per net ton of strip			
	1939	1940	1941	1942
January	10.2	11.9	7.2	4.7
February	14.0	10.7	2.9	5.3
March	10.1	10.7	3.7	4.3
April	11.4	8.3	4.3	4.8
May	11.7	6.0	5.3	4.0
June	15.5	4.5	5.4	3.6
July	14.0	5.2	5.1	3.3
August	12.1	6.4	5.0	2.6
September	9.8	8.3	4.9	2.5
October	8.7	6.3	4.6	2.1
November	10.1	6.9	4.5	2.2
December	10.4	7.7	5.1	3.2

possible feed line from the feeders to the mill. To prevent the oil-water mixture from draining from the feed lines when the mill stopped, it was necessary to install spring loaded check valves in the ends of the feed lines. These check valves opened at 35 lb and closed at pressures below this figure. As it was found impossible to keep the valves from leaking, it was finally decided to move the feeder pumps to a position below the mill, thus eliminating the check valves. This new location required the installation of longer feed lines from the pumps to the mill, but with adequate heating, the arrangement has been a success.

Figure 5 shows a schematic layout of the palm oil-water mixture control as now installed.

Table I shows the rate of palm oil per net ton of strip from 1939 through 1942. Note the improvement in oil rate that occurred in April, 1940, when the tests on palm oil and water mixture were first started on No. 2 mill. In June, when the mixture was extended to No. 1 mill, the rate again dropped. As cold weather approached, the rate showed a tendency to increase slightly, due to segregation caused by lack of recirculating capacity and by the long recirculating lines. When our present equipment was first installed in January 1941, the oil rate assumed another lower level, where it remained until June 1942, when the final relocation of the feeders was made. Since this date the oil rate has averaged 2.5 lb per ton, a reduction of 9.0 lb, as compared to the 1939 rate. However, during December the rate increased to 3.2 lb per ton of strip rolled. This increase was caused by the use of straight palm oil on one mill for a short time during the repair of the recirculating pumps, which had become badly worn.

With a mill production of 500,000 tons of strip per year, a reduction in palm oil of 9.0 lb per ton of strip represents a saving of 4,500,000 lb of oil annually. This decrease in consumption for strip rolling has effected a relative increase in our storage capacity for palm oil of 300 per cent.

Because of the reduction in the amount of palm oil used, the procurement problem of scheduling palm oil into our plant has been greatly relieved. Since the procurement of palm oil has been materially affected by the war, any decrease in the consumption is highly desirable.

DISCUSSION

PRESENTED BY

A. J. FISHER, Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

J. T. ROACH, Superintendent of Cold Rolling, International Nickel Company, Huntington, West Virginia

C. E. DUFFY, Assistant Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

W. H. BEYERLE, Assistant Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Maryland

A. J. FISHER: You may wonder why we use straight palm oil. Perhaps some of you know about the progress of oiling strip on other mills. In the use of palm oil we find a very singular effect in going through the rest of the particular process. The cold strip as rolled, when palm oil is used, comes out of the mill very shiny and bright. Any of the other oils that have been used as a substitute for palm oil have come out of the mills rather dark, and quite a bit of the carbon in the oil has been broken down and imbedded itself in the pores of the steel. Now in going through the washers this carbon is not washed out, and when the strip goes through the annealing process, the carbon is burned in the pores of the strip. It is almost impossible to pickle these carbon particles out of the pores of the strip, and in the tinning process, the tin bridges over the carbon particles and some acids and some fluxes are retained in these depressions and around the carbon particles which later permeate out and disrupt the tin coating — so we stayed with the use of palm oil, and have tried to decrease the amount used per ton of strip rolled.

J. T. ROACH: I was just wondering if there was any way that oil can be reclaimed and refiltered and used over?

C. E. DUFFY: Yes, but we do not use enough oil to pay to reclaim it. Our records over the last six months show a refuse credit of 7 mills per ton of steel.

A. J. FISHER: There is about a pound of palm oil per ton of strip retained on the strip, so that you have only about a pound and a half going down in the cold mill sump, a very small amount to play with as far as reclamation is concerned.

MEMBER: What do you do if you can't get palm oil at all?

A. J. FISHER: In answer to the question of what we would do if we couldn't get palm oil, I might say we have run on other oils. We can operate, although the amount of oil used in the process is very high and it is more expensive than palm oil. But we can use mineral or vegetable oils, or a combination of both.

(*Please turn to page 39*)

MODULATOR *Control* FOR *Multi-Fuel* FIRED FURNACES

. . . . with the increased use of two or more fuels in one furnace, the development of automatic control for multi-fuel firing assumes greater significance . . . .

by C. J. Geiser, ENGINEER

REPUBLIC FLOW METERS COMPANY

CHICAGO, ILLINOIS

▲ DURING recent years, the general picture of fuels available for steel plants has undergone considerable change. Most plants now have a diversity of fuel supply which was not previously available and this permits better fuel distribution to the mills with a choice of fuels at the various furnaces. Many furnaces in these plants are equipped to use two or more fuels simultaneously and in combinations, depending upon availability, respective costs, or furnace operation.

The automatic control of combustion air on any furnace using more than one fuel, fired simultaneously, has always involved the problem of summarizing the fuel flows to obtain an index for air flow control. Several designs of controls have been used for this purpose, each having a different degree of complexity in its design. The initial problem which faces all of these designs is to summarize linear functions (fuel flows) when the index of each function is a square root function (flow differential). This square root function is involved in all measurements of fluid (gas or liquid) flow by means of a thin plate orifice, flow nozzle, venturi tube, etc., and in some methods of obtaining a measurement in conjunction with a rotary meter.

Multifuel control also often involves problems of preferential firing of fuels, total fuel input control and other similar problems, as well as the problem of total combustion air control. In addition, all multifuel controls must provide flexibility of adjustment required to correctly compensate for air infiltration.

PRINCIPLE OF MODULATOR CONTROL

A novel and simple means of correctly summarizing two or more fuel flows, is by the use of modulators. The modulator consists of an inclined U-tube operating on a force balance principle. Figure 1 illustrates the square root modulator with diaphragm measuring element sensitive to the input loading air pressure, or flow differential. The force transmitted from the diaphragm element to the U-tube assembly unbalances the tube and controls the air bleed at the multiplying valve. The resulting air pressure at the multiplying valve is piped to the outer leg of the U-tube and the travel of mercury within the tube produces a force which balances the force from the measuring diaphragm. Thus, the resulting air pressure from the multiplying valve is a function of the input loading pressure, or differential, and this resulting air loading pressure is the output static loading pressure from the unit. The relationship of these pressures is that the output pressure is proportional to the square root of the input pressure or differential.

Using square root modulators on multifuel applications, a static air loading pressure is established which is a linear function (directly proportional) to each fuel flow. These static air loading pressures (one for each fuel) being linear, may be directly totalized to provide an index of total fuel flow, on a diaphragm type pressure totalizer, shown in Figure 2. The unit shown is designed for two fuels and this design is also used for three fuel totalization. Fuel loading pressures are impressed on the two left hand diaphragm assemblies. The unbalance of the totalizer weighbeam produces a totalized, balancing static air pressure under the righthand diaphragm, by the control of air bleed at the multiplying valve at the extreme right of the case. Piping connections and multiplying valve block are on the underside of the case.

The output static loading pressure from the totalizer is used as an index of the total combustion air requirement. However, before this pressure is used to control the combustion air flow regulator, the square function

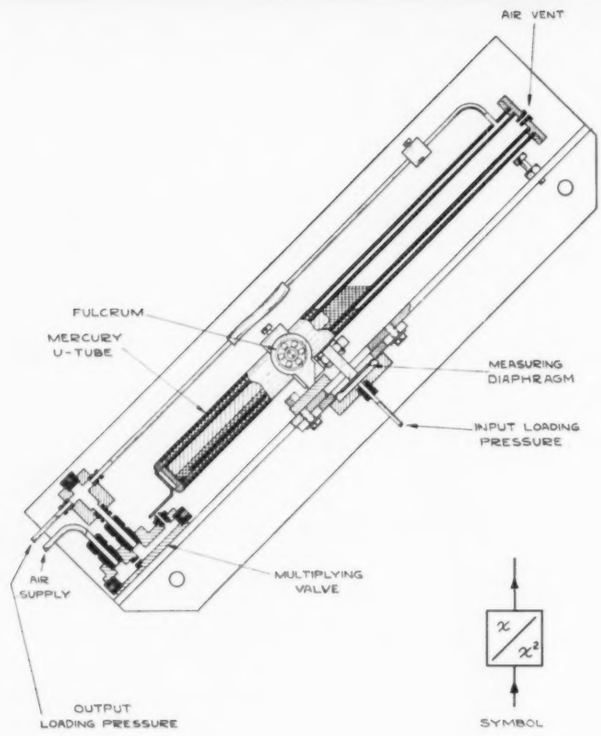


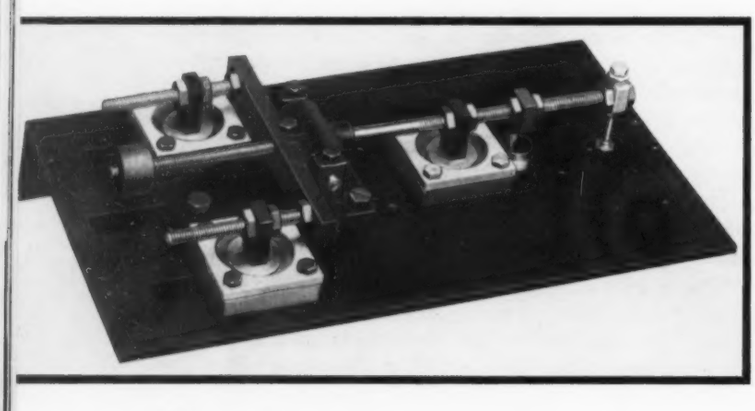
Figure 1 — Sketch showing the square root modulator with diaphragm measuring element sensitive to the flow differential.

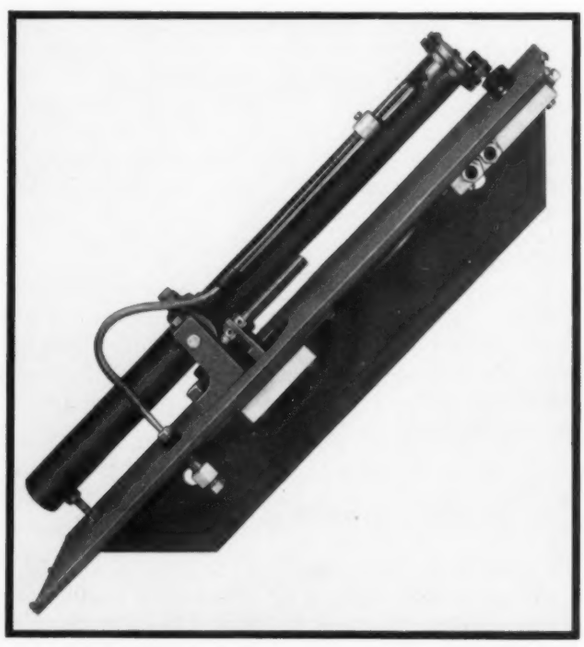
must be replaced to correctly balance against the air flow differential. This is accomplished by the squaring modulator shown in Figure 3, an inverse arrangement of Figure 1. The output static air pressure of the squaring unit is proportional to the square of the input pressure.

The inclined U-tube modulators always produce square root or squaring relationships between input and output loading pressures. This meets the requirements of the vast majority of multifuel control applications, using correctly designed flow orifices in fuel and air lines, and using speed measurement as an index for some fuels. A cam operated modulator, however, can be shaped especially to fit any particular, unusual characteristic.

Figure 2 — (below) Diaphragm type pressure totalizer which provides an index of total flow for two fuels.

Figure 3 — (right) The squaring modulator, with an output pressure proportional to the square of the input pressure, is balanced against the air flow differential.





APPLICATIONS OF MODULATOR CONTROL

Providing static air loading pressures which are directly proportional to fuel flow, the modulator system proves very flexible in application. A few of the interesting applications for this design are shown in the following diagrams. These diagrams show applications for two fuels fired simultaneously, although many control systems may be enlarged to control three, or possibly four, fuels.

1. Figure 4 illustrates the manual control of two fuels with automatic control of combustion air. This application is common on open hearth and other types of furnaces where automatic temperature control is not practical, or desirable. The flow differential of each fuel flow is measured by the differential diaphragm of a square root modulator, and the output pressures of the modulators are directly proportional to the respective fuel firing rates.

To correctly adjust a multi-fuel control for changes in Btu, specific gravity and air requirements of the fuels, means for adjustment must be provided which are independent for each fuel. Thus, fuel No. 1 may increase in Btu and consequently increase in air required for combustion, while fuel No. 2 remains constant in these respects. This requires increasing the combustion air flow-fuel flow ratio for fuel No. 1 only, leaving the

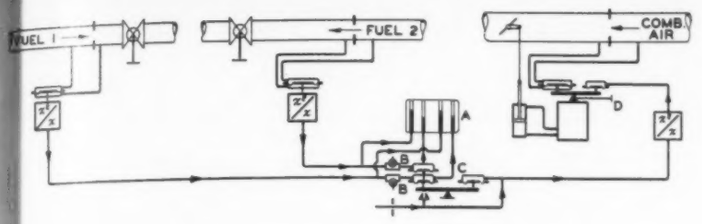


Figure 4 — Sketch showing arrangement for manual control of two fuels with automatic control of combustion air.

ratio for fuel No. 2 unchanged, to give the correct totalized fuel-air ratio for all rates of fuel firing. Adjustment of the totalized fuel-air ratio in such a case would be correct for one rate of firing of both fuels only, but would not be correct for other rates of firing.

The modulator type of multi-fuel control presents a convenient method of correctly adjusting fuel-air ratios individually for each fuel, and the novel solution of this problem will become more apparent in connection with the other diagrams.

Referring to Figure 4, mercury manometer gauge "A" indicates the firing rates of the fuels at the first and third tubes. Ratio bleeder valves "B" provide individual adjustment of the loading pressure for the air requirement of each fuel, and the adjusted pressures are shown at the second and fourth manometer tubes. Since all static loading pressures at the manometer are linear functions of fuel and required air flow, all manometer scales have equally spaced units and divisions. The indicating scales for the second and fourth tubes are compressed so that the required excess or deficiency of air adjustment from normal, can be obtained by adjusting valves "B."

The output static pressures from valves "B", being linear functions proportional to the required combustion air flow, are totalized at totalizer "C." The resulting totalized loading pressure is a linear function of total air required, and this pressure is impressed on a squaring modulator to obtain the correct characteristic for combustion air control.

Although the above described system illustrates a correct method for the adjustment of fuel-air ratio on a multi-fuel installation, such a system always encounters obstacles because the adjustments must be made by the furnace operators. Any correct method of ratio adjustment would always involve an independent ratio setting device for each fuel fired, and the additional adjusting devices involved are usually beyond the practical use of first helpers and heaters on steel mill furnaces. For this reason, a single fuel-air ratio adjustment "D" at the combustion air regulator has been provided with a suitable, calibrated ratio setting indicator. As previously explained, a single ratio setting adjustment on a multi-fuel control cannot be strictly correct except when the orifice differentials measuring the fuels are consistent functions of the air required for combustion. The single adjustment will not be correct whenever the measured orifice differentials do not represent the quantity and quality of fuels for which the control was calibrated. The errors introduced in turn, may result from changes in fuel density, temperature, pressure, saturation or composition. The limitations of the single ratio adjustment "D" at the regulator must therefore be weighed against the operator's ability and willingness to successfully make the proper individual adjustment for each fuel.

Methods of adjusting the control to compensate for air infiltration are described under heading number eight, below.

Arrows shown on Figure 4 and on the other diagrams indicate the direction or sequence of static loading pressures and do not indicate any flow of master loading air in control lines except for slight bleed out at the ratio valves.

2. Figure 5 illustrates automatic flow control of fuel No. 1, manual control of the fuel No. 2, and automatic combustion air control. Figure 5 is similar to Figure 4 except that automatic flow control has been added for fuel No. 1. A flow control subpanel "E" with pressure setting gage and handwheel permits the operator to manually adjust the constant flow of fuel No. 1 required. The regulator controlling fuel No. 1 maintains a constant flow differential at the metering orifice, in accordance with the setting at subpanel "E." Modulators are provided to give linear air pressure vs. flow relationships at all connections to the totalizer.

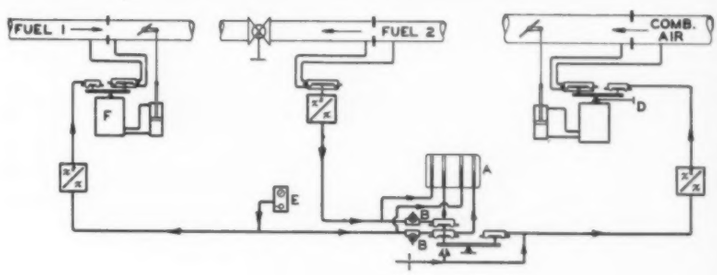


Figure 5 — Arrangement for automatic control of one fuel, manual control of second fuel, and automatic control of combustion air.

Similarly, automatic fuel flow control on two or more fuels with totalization for combustion air is obtained by extension of the principle shown for fuel No. 1 to other fuels and totalizing in the same manner.

Referring to Figure 5, it will be noted that the use of individual ratio valves "B" for air flow adjustment for each fuel does not disturb the correct operation of the fuel flow control. The loading pressure from subpanel "E," through the modulator and to the fuel flow regulator "F" is not subject to adjustment for obtaining the correct fuel-air ratio. Also, the variable fulcrum of the fuel flow regulator is fixed in position after initial calibration for the system and is not subject to further adjustment. Therefore, duplication of pressure settings at the subpanel will always repeat the exact orifice flow differentials measuring fuel No. 1. The use of ratio valves for correct fuel-air ratio adjustment properly

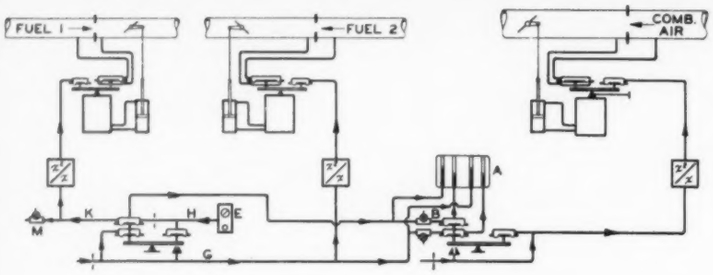


Figure 6 — (above) Arrangement for total heat input control, with proportional control of primary and secondary fuel and automatic control of air.

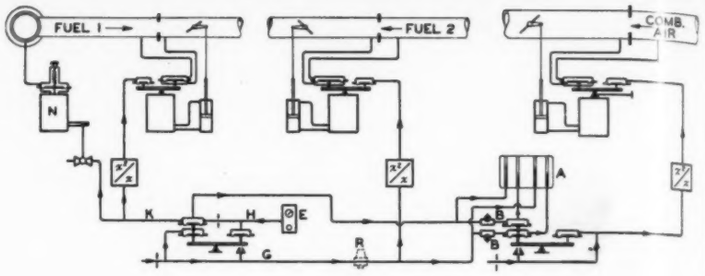


Figure 7 — (top right) Arrangement for total heat input control, using available primary fuel, automatic make-up on secondary fuel, and automatic control of air.

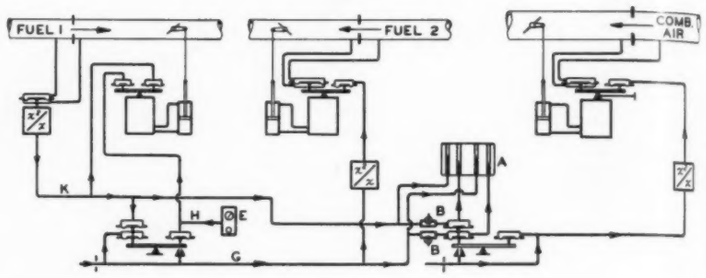


Figure 8 — (lower right) Another arrangement similar to that of Figure 7 except that fuel No. 1 is fired in the required quantity regardless of fuel main pressure.

adjusts only the individual pressure impulse for combustion air control.

3. Figure 6 illustrates total heat input control with proportional control of fuels No. 1 and 2 and automatic control of combustion air. The use of the totalizer in a reverse manner to subtract one pressure value from a second, giving a third pressure value, equal or proportional to the difference, permits a great variety of applications. Figure 6 illustrates such an application with loading pressure "G" equal to the difference between pressures "H" and "K." A total heat input subpanel "E" is adjusted by the operator for total heat input. Ratio valve "M" permits proportioning the flow of the two fuels in any desired ratio by reducing pressure "K" to a value less than "H." Pressure manometer "A" at the first and third tubes, indicates the firing rates adjusted at the ratio valve "M" and all indicated loading pressures at the gage and manometers are linear functions of flow. The total heat input is indicated on the pressure gage of subpanel "E" and is more accurately indicated by the sum of the two mercury column heights at the manometers.

To obtain the correct relation of loading pressure vs. flow differential, equal Btu input for each fuel per unit of loading pressure based on the average Btu values, is calibrated at the individual fuel regulator weighbeams. After calibration the fuel regulator weighbeam settings are not subject to further adjustment by the furnace operators.

The balance of the control system with fuel flow totalizer and combustion air control, corresponds to the system previously described.

The use of the individual ratio valves "B" for air flow adjustment of each fuel again does not disturb the calibrated pressure values used for fuel proportioning control. Duplication of pressure settings at the subpanel "E" and at the first and third tubes of manometers "A" will always repeat the exact orifice flow differentials measuring the fuels. Ratio valves "B" properly adjust only the combustion air flow due to their location in the totalizing control system.

4. Figure 7 illustrates total heat input control using the available supply of fuel No. 1 with automatic make-up of fuel No. 2 and combustion air control. Figure 7 is similar to Figure 6, except for the automatic control of fuel No. 1, and the proportioning of fuels in accordance with the availability of fuel No. 1. An availability regulator "N" measures the line pressure of fuel No. 1, and the fuel regulator provides firing of fuel No. 1 only, as long as the fuel pressure is above a predetermined minimum value. When the minimum fuel pressure is reached, the availability regulator partially bleeds the loading pressure to the fuel regulator, causing the fuel regulator to reduce the firing rate to the extent necessary to maintain minimum fuel pressure. Loading pressure "G" is then automatically established equal to the difference between pressures "H" and "K," automatically restoring the firing of fuel No. 2 to the extent required to maintain total heat input, as adjusted at "E."

The balance of the totalizing control for combustion air is identical to Figure 6, and the ratio valves for fuel-air ratio adjustment provide a correct method of adjustment without disturbing the calibration of the fuel flow controls.

5. Figure 8 illustrates total heat input control using the available volume of fuel No. 1 with automatic make-up of fuel No. 2, and combustion air control. Figure 8 is similar to Figure 7, except that fuel No. 1 is fired in whatever quantity required regardless of fuel main pressure. If a surplus of fuel No. 1 is available, the fuel regulator reduces the firing in accordance with the setting of the total heat subpanel "E." If a sufficient quantity of fuel No. 1 is not available, fuel No. 1 control valve reaches full open position, and fuel No. 2 is automatically fired to make up the total heat requirement. Again this is accomplished by establishing load-

ing pressure "G" equal to pressure "H" minus "K."

The balance of the control system is identical to the systems described above.

6. The provision of linear, static air loading pressures obtained from the modulators permits the use of minimum firing rate control on any system which includes fuel flow regulators, such as shown in Figures 5, 6, 7 and 8. Thus a minimum air loading pressure for minimum firing rate is predetermined for each fuel and is used to continuously load the fuel flow regulator and the fuel totalizer. Since all loading pressures in this part of the system are linear functions, the correct total combustion air flow is established. To illustrate, a minimum pressure relay "R" is shown in Figure 7 for control of fuel No. 2. This relay would establish a minimum loading pressure for fuel No. 2, when pressure "G" was below the minimum, loading the fuel regulator, fuel totalizer and pressure manometer.

7. Automatic control of fuel firing rate by temperature controllers may be included on any of the complete control installations. This is accomplished by motor operated fuel valves actuated by the temperature controller, replacing the manually operated fuel control valves shown in the above diagrams. On the more elaborate control systems, such as Figures 6, 7 or 8, the temperature controller actuates an air loading pressure to replace the total heat input subpanel pressure "E." A three-way transfer valve in the air loading lines permits manual control of this actuating control pressure at subpanel "E," completely disconnecting the automatic temperature controller.

8. Compensation of the modulator system for air infiltration permits a very flexible adjustment to match almost any required characteristic. This compensation is obtained by the correct weight loading of the totalizer weighbeam and/or the correct weight loading of the combustion air regulator weighbeam. Since the static air loading pressures at the totalizer are linear with respect to combustion air flow, weight loading the totalizer weighbeam provides a correction for a constant amount of air infiltration, independent of firing rate or proportion of fuels being fired. However, weight loading of the combustion air regulator weighbeam provides a correction for an increasing or decreasing (depending on the direction of unbalanced force) amount of air infiltration with an increase in firing rate. Thus, by the correct combination of unbalanced weight at these two weighbeams, practically any characteristic may be correctly matched.

In addition to the possibilities above outlined for compensation of air infiltration, a minimum flow of combustion air may be readily established if required by the burner design, or if required on regenerative furnaces. This is accomplished by the use of a minimum pressure setting relay connected at the output pressure line of the totalizer. This relay is identical to the minimum relay "R" described above, and connection at the totalizer output line would be similar to that shown for minimum fuel control on Figure 7.

DUFFY *Discussion*

(*Continued from page 34*)

W. H. BEYERLE: What will happen if you don't use any oil at all?

A. J. FISHER: Palm oil is a power saver for the strip going through the mill. If you don't use any palm oil or if you should decrease the palm oil from the regular amount down to zero you find the power consumed in the mill would be considerably more.

W. H. BEYERLE: And how about using just water?

A. J. FISHER: Water will not do the job. I think in seeking a substitute for palm oil one should try to get an oil that is non-soluble. This system we have shown here is a non-soluble system — that is, the oil and the water is a mechanical mixture. It is an emulsion, too, but we prefer to look at it as a mixture. In rolling cold strip there is a lot of water used on the mill, and if you use a soluble oil the water washes a large amount of the soluble oil off the strip and down into the sewer. In using a mixture, which is not soluble, that part of the oil which is by itself will stick to the strip and will feed itself into the mill and not be washed off. That, by the way, is the secret of this palm oil and water system. The oil is not washed off the strip. The soluble oils are.

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Water Hammer IN THE HYDRAULIC Spray System

. . . . the author investigates factors contributing to the magnitude of water hammer in hydraulic systems . . . . the effect of suction and discharge header sizes, of spray valve size and operation, and of accumulator location are considered . . . .

by J. S. Fulton

PITTSBURGH, PENNSYLVANIA

▲ PRIOR to the development of the continuous strip mill a light gauge sheet was produced by several heating and rolling operations. Between each operation the piece was inspected and blemishes and scale were removed in various ways. In the continuous strip mill, where the slab is rolled to the finished light gauge strip with neither intermediate heating nor inspections, the scale is removed by the impingement of jets of high pressure water at several locations in the mill train.

The tenacious furnace scale must be loosened by distorting the slab in a scale breaker before the slab enters the first spray station located ahead of the first stand of roughing rolls. The piece is resprayed at subsequent stations in order to insure removal of any residual furnace scale and of any mill scale produced by the action of the rolls on the piece in the presence of atmospheric oxygen. In a sense, the acuteness of the sprays is substituted for the acuteness of inspection in the other process.

There are at least three different theories as to the action of the hydraulic spray in removing scale.

A. The jet of water acts like a knife and pares the scale from the slab or strip.
B. The jet of water gets under the scale and the resultant formation of steam blows the scale from the slab or strip.
C. The jet of water cools the scale more than the piece and the contraction cracks the scale from the slab or strip.

It is probable that the scale is removed by some combination of these three actions.

PRESSURES USED IN SPRAY DESCALING

The pressure on the sprays has advanced from the 500 psi tapped off a "hydraulic system" for the first continuous mills to the 800 to 1200 psi now used. As will be seen later, the intensity of the water hammer encountered has no relation to the nominal header pressure.

The pump delivers water to a header supplying one or more spray stations, consisting of a control valve and a header on which is mounted the spray nozzles. The valves are actuated by various means. Their closure presents the possibility of the formation of water hammer. Since water hammer may be generated, it will be advisable to determine its magnitude and rate of propagation. The following formulae are found in R. L. Daugherty's book on "Hydraulics," to which the reader is referred for the details of their development.

VELOCITY OF PROPAGATION OF WATER HAMMER

In any header in which the water is brought to rest by the closure of a valve a wave of pressure WH (called a water hammer) is initiated on the face of the valve and propagated throughout the water at this velocity:

$$(1) \quad V\ (\text{fps}) = 4700\ (\text{fps}) \sqrt{\frac{E}{E + e\,\frac{d}{t}}}$$

The variation in the value of V caused by the diameter and thickness of Class 80 and Class 160 steel pipe are shown on Table I and II and in Figure 1.

In a header having a length in feet L, between the valve N and the reservoir R (or pump P), the WH will travel from N to R in:

$$(2) \quad T\ (\text{sec}) = \frac{L \text{ in feet}}{V \text{ fps}}$$

At the end of T (sec) WH disappears in the reservoir, the water in the header is at rest and another wave of pressure WH starts from R and reaches N in T (sec).

CRITICAL TIME OF VALVE CLOSURE FOR MAXIMUM VALUE OF WH

It has been found that the magnitude of WH is independent of the time of valve closure, provided that it is closed in less than 2T (say in 2T′), the time in seconds needed for the round trip of WH. The values of 2T are shown on Tables I and II and in Figure 1.

It must be noted that a closure in $2T' < 2T$ will not increase the magnitude of WH but it will increase the distortion of the header proportional to the value of $2T/2T'$.

If the time is extended to $2T'' > 2T'$ then

$$(3)\quad WH'' = \frac{WH \times 2T}{2T''}$$

The total force in bringing the water in motion in the header to rest may be determined by applying the principal:

(4) Force = mass x acceleration and then by appropriate steps transforming force into WH (psi):

$$(5)\quad WH = \frac{v \times V}{2.31 \times g} = \frac{v \times V}{74.38} = 60 \text{ psi per 1 fps quenched}$$

The values are shown on Tables I and II and in Figure 1.

Values of 400 to 600 psi for WH are common and 1000 psi has been reported.

Equation 5 was derived for a header with only one diameter and one water velocity, but what will be the composite value of WH for this case?

	Main header	Nozzle header	Valve
Fps velocity	3	9	36
Psi WH	180	540	2160

Until actual readings are obtained by suitable instruments, this question must remain unanswered, but until then it will be advisable to use low water velocities right up to the nozzles.

In a header having a multiple number of valves, or in a header with only one valve, it is possible that the sequence of valve closures may impose another WH′ on top of a previous WH, etc., until the header bursts.

While few headers have ruptured, the possibility of such a sequence is another argument in favor of low velocity.

TABLE 1 — Class 80 Steel Pipe

1. Nominal pipe size, in.	4	6	8	10	12
2. O.D., in.	4.500	6.625	8.625	10.750	12.750
3. Wall thickness, in.	.337	.432	.500	.593	.687
4. Velocity WH, fps.	4,415	4,392	4,340	4,324	4,317
5. 2T sec, 250 ft header	.113	.114	.115	.116	.116
6. 2T sec, 500 ft header	.226	.228	.230	.232	.232
7. 2T sec, 750 ft header	.340	.342	.345	.348	.348
8. 2T sec, 1000 ft header	.453	.456	.460	.464	.464
9. WH psi 3 fps velocity	178	177	175	174	174
10. WH psi 6 fps velocity	356	354	350	348	348
11. WH psi 9 fps velocity	534	531	525	522	522
12. WH psi 12 fps velocity	712	708	700	696	696

TABLE II — Class 160 Steel Pipe

1. Nominal pipe sizes, in.	4	6	8	10	12
2. O.D., in.	4.50	6.625	8.625	10.75	12.75
3. Wall thickness, in.	.531	.718	.906	1.125	1.312
4. Velocity WH, fps	4,500	4,510	4,490	4,490	4,490
5. 2T sec, 250 ft header	.111	.111	.112	.112	.112
6. 2T sec, 500 ft header	.222	.222	.223	.223	.223
7. 2T sec, 750 ft header	.333	.332	.334	.334	.334
8. 2T sec, 1000 ft header	.444	.443	.445	.445	.445
9. WH psi 3 fps velocity	181	182	181	181	181
10. WH psi 6 fps velocity	362	363	362	362	362
11. WH psi 9 fps velocity	543	545	543	543	543
12. WH psi 12 fps velocity	725	726	724	724	724

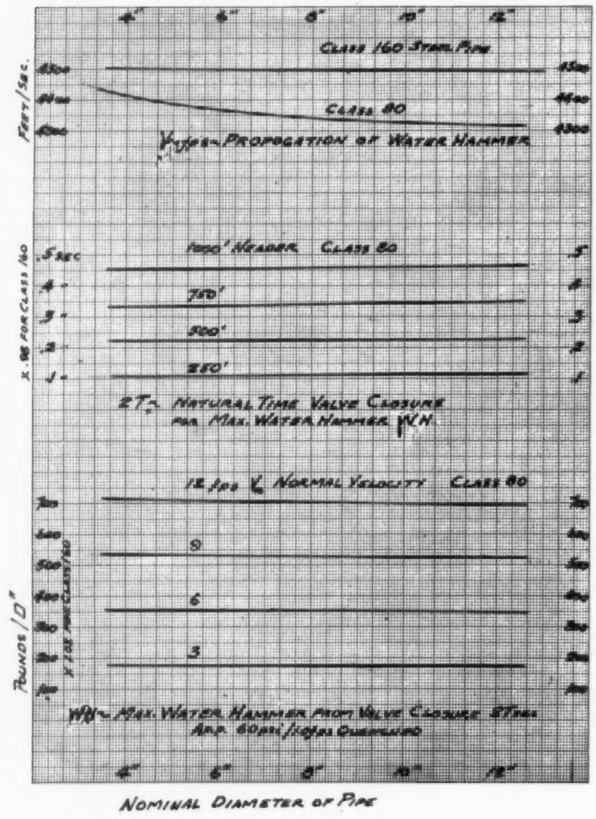


Figure 1 — Chart showing effect of header design on magnitude of water hammer and its velocity of propagation.

INFLUENCE OF HEADER DIAMETER ON MAINTENANCE

Equation 5 shows that the magnitude of WH is directly proportional to the maximum velocity in the header and can only be decreased by an extension of the time of valve closure $2T'' > 2T$. Consequently, the designer selects the future magnitude of WH when he selects the header diameter, because the diameter determines the maximum water velocity, i.e., with 10 fps, WH = 600 psi, and with 3 fps, WH = 180 psi. With 10 fps velocity in the header it would be necessary to make $2T'' = 10/3 = 3\frac{1}{3} \times 2T$ natural in order to decrease WH to 180 psi. This would require more pumping power.

LOCATION OF SURGE TANK

If apparatus is added to the header to minimize the formulation of WH, it is obvious that it must be applied in the same manner and at the same location. The surge tank near the control valve of a hydraulic turbine (Figure 2) eliminates the formation of WH from the valve closure and boosts nozzle pressure when the valve reopens, because

A. It provides storage space for the water rejected by the valve closure and while the pressure at N rises to $H_k > H_s$ yet $H_k < WH$.

B. It provides gallons immediately upon the opening of N so while the pressure drops to $H'_n < H_n$ corresponding to v velocity, yet $H'_n > H''_n$ needed when all of the water in the header must be accelerated when there is no surge tank near N.

If a surge tank were installed near the discharge end of a spray descaling header, it would benefit the operation in the same ways.

If no surge tank is used near the discharge end of the header, there is no adjacent space available for the storage of rejected water, WH is formed in accordance with equation 5 and $WH > H_k$.

When N reopens it is necessary to accelerate all of the water in the header, consequently the nozzle pressure drops to $H''_n < H'_n$.

The surge tank now called a hydro-pneumatic accumulator is usually found on a branch of the header near the pump (Figure 3). In order to prevent backward rotation of the pump from a failure of motive power, a check valve is inserted at the pump discharge.

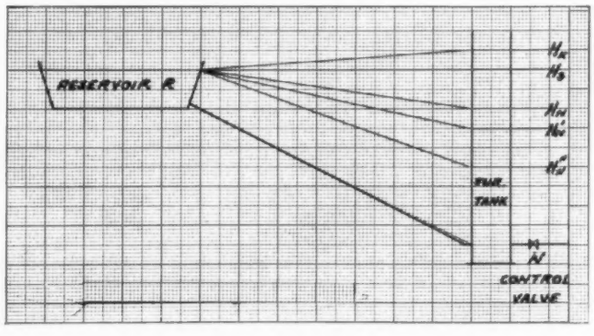
It is obvious that storage space available near the pump cannot be used to store water rejected at the other end of the header. Consequently, WH is generated by the closure of N and proceeds toward the pump at a velocity of about 50 miles per minute.

When WH reaches the check valve, it either passes through and into the pump with undiminished intensity or is stopped by an instantaneous closure of the valve.

If the valve disc was 1/10th foot off its seat, the closure must take place in $2T' < 1/45000$th of a second, in order to prevent the original value of WH from entering the pump casing.

But it must be noted that this closure of the check valve stops the flow of water from the pump and consequently creates another water hammer with a value of WH′ probably greater than WH because of the higher water velocity in this section. If the distance is 4.5 feet between the check valve and the tip of the discharge impeller the new value for the time of valve closure $2T''$ would approximate 2/1000th of a second.

Figure 2 — A surge tank near the control valve of a hydraulic turbine eliminates water hammer from the valve closure.



But since $2T'$ is 90 times less than $2T''$, the check valve closure causes greater distortion of the pump casing and unbalance of the pump rotor, than if the check valve had not closed and so allowed the original value of WH to enter the pump.

Therefore the check valve can not diminish the effect of water hammer on the pump parts and so can not decrease the major course of pump maintenance.

The wave of water hammer entering the pump casing must be destroyed by the kinetic energy of the water in motion in the pump casing, since otherwise the wave of water hammer would appear in all of the yard lines.

While the check valve may prevent WH from getting into the pump, WH moves unimpeded into the accumulator and reaches the surface of the water column where WH disappears just as it does in the reservoir on Figure 2. WH has no more effect on the absolute pressure of the air on the surface of the water column in accumulator than it has on the barometric pressure on the surface of the reservoir. Therefore, the air column is not compressed by the impingement of WH.

WH readings taken on a spray header with the hydro-pneumatic accumulator shut off, or by negligence

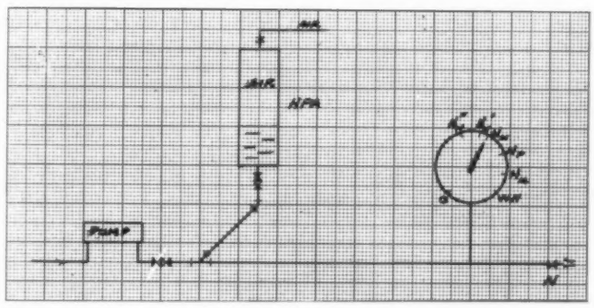


Figure 3 — Many installations place a hydro-pneumatic accumulator near the pump discharge.

full of water, show no significant difference from those taken with the accumulator in service with a full air column.

During idle periods the pump stores water in the accumulator at a pressure P_1, which becomes P_2 when the valve opens and water is delivered to the header. For simplicity we will assume that the rate of delivery from the accumulator and the pump are equal. The velocity in the entire header becomes v fps, and the probable value of WH becomes 60 psi x v fps.

With the accumulator near the valve the velocity up to that point would be v/2 and beyond the accumulator would be v. Even though v exists between the accumulator and N, no WH is formed. Consequently, the accumulator near the pump increases the magnitude of WH created by the closure of N.

The wave of pressure, WH, starts from the valve N at a velocity of about 50 miles per minute and passes the tee upon which the spring loaded alleviators are mounted at that velocity. Unless the alleviator can open faster

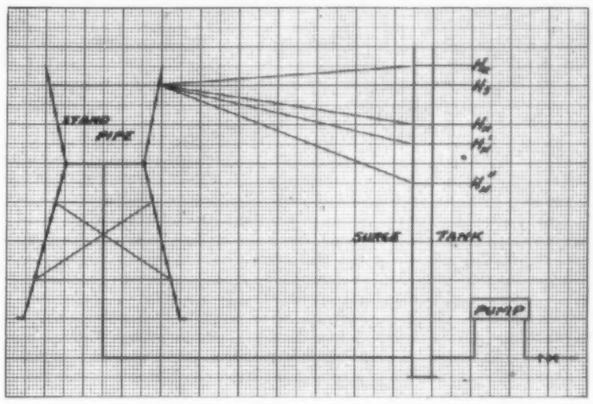


Figure 4 — A suction surge tank is recommended if suction header velocity exceeds 3 fps.

than the time it takes the wave to pass this opening, the wave will continue toward the pump with undiminished intensity. If the opening was .25 feet wide, the time of valve-opening must be less than 1/18000th second.

Now that we have explored the formation of WH on the discharge and the prevention of its formation by the proper location of the hydro-pneumatic accumulator, we will study the formation of WH in the suction header. As in the discharge header, the velocity selected for the suction header determines the magnitude of WH.

When N is opened on the discharge header, unless there is a surge tank at the pump suction the water must be accelerated in the suction header clear back to the standpipe in the yard. The suction pressure, due to the pull of the pump, drops from H_s to H''_n, rises to H_n as the water accelerates where it remains until N closes. Since the pump cannot deliver against the closed check valve or against the WH in the discharge header, it rejects the water in motion in the suction header and WH_s is formed.

The following readings were taken at installations with restricted suction lines and no accumulator at the end of the discharge header.

	Single pump			
Position of N on discharge header	Shut	Open	Shut	Shut
Psi, suction	20	—12	255	20
Psi, discharge	1080	1000	1490	1080
	First pump of series unit			
Position of N on discharge header	Shut	Open	Shut	Shut
Psi, suction	35	5	210	35
Psi, discharge	515	430	860	515

When a surge tank was installed near each pump suction (Figure 4) the suction pressure dropped only about five pounds. The cost of maintenance was decreased 80 per cent.

In order to illustrate the tremendous influence of the addition of a few gallons in a few seconds, we will con-

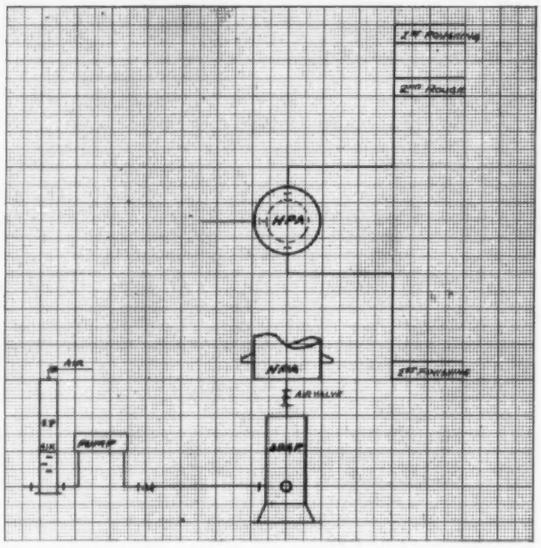


Figure 5 — Location of the hydro-pneumatic accumulator near the point of water usage is recommended.

sider a suction surge tank 20 feet high, half air and half water, with an area of 3 square feet, when the header and air pressure drops from 35 to 30 psi gauge pressure in 5 seconds. This will increase the rate of delivery to the pump by the equivalent of:

$$(6)\ 3 \times 7.5 \text{ gal per cu ft} \times 10 \text{ ft.} \left(\frac{35+14.4}{30+14.4} - 1\right) = 25 \text{ gal}$$

But since these 25 gallons are delivered in 1/12 minute, they increase the rate of pump delivery by 300 gpm. If this surge tank was installed on the discharge header, it would also contribute at the same rate for a 10 per cent drop in header pressure.

To illustrate how well a pump can get along with moderate header velocities, a spray pump ran for 6 years without shutdown from mechanical failure and without replacement of parts with:

A. 3 fps suction velocity but without a suction surge tank and with

B. 5 fps discharge velocity but without an accumulator.

CONCLUSION

There is no way to avoid the results of water hammer once it is generated. Since WH is proportional to the velocity quenched, the lower the velocity, the lower the shock. If it is not possible to obtain 3 fps in the suction header, then a suction surge tank should be used as is shown in Figure 5. If the balance between diameter of discharge header, pump size and maximum rate of gallons demanded by spray operation favors the use of a hydro-pneumatic accumulator, it should be installed somewhat as shown in Figure 5 in order to reap the greatest benefits. Consideration should also be given to the use of larger spray valves and longer closing time.

NOMENCLATURE

d	— Outside diameter of header, inches.
E	— Modulus of elasticity, in tension, in the wall of header = 30,000,000.
e	— Modulus of elasticity, in compression, of the water in the header = 300,000.
fps	— Feet per second velocity.
g	— Acceleration of gravity = 32.2.
H_k	— Increased head at N upon closure of N in system with surge tank at N.
H_n	— Normal head at N with N open and flow stabilized.
H'_n	— Temporary head at N upon opening N in system with surge tank at N.
H''_n	— Ditto without surge tank, $H''_n < H'_n$.
H_p	— Pressure at N with zero flow from pump, also shut-off pressure of pump.
HPA	Hydro-pneumatic accumulator.
H_s	Static pressure at N with zero flow from reservoir.
H_w	— Total pressure at N upon closure of N in system without accumulator.
L	— Length of header in feet.
N	— Valve.
P_1	— Pump.
P	— Pressure in accumulator before sprays open, psi.
P_2	— Pressure in accumulator after sprays open, psi.
PN	— Length of pump discharge header.
psi	— Pounds per square inch gage pressure.
R	— Reservoir.
T	— Seconds for travel of water hammer, WH from N to P or R.
$_2T$	— Natural critical time of valve closure in seconds.
t	— Thickness of one wall of header, inches.
v	— Velocity at normal flow in header, in fps.
V	— Velocity of propagation of WH in header PN
4700 fps	— Velocity of transmission of sound in water, ft per sec.
WH	— Water hammer superposed on the header pressure, psi.

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ALTERNATING CURRENT *Welding in the* STEEL INDUSTRY

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by Emil Steinert and W. W. Reddie

WESTINGHOUSE ELECTRIC & MFG. CO.

PITTSBURGH, PENNSYLVANIA

▲ THE subject implies a discussion of a-c welding in the steel industry as such. The authors believe that limiting the paper to specific applications found in your industry, broad as it is, would restrict its value. Consequently we have taken the liberty of planning the paper to cover many of the questions now being asked about a-c welders both on equipment and application.

In the public interest, some of the most interesting developments cannot be mentioned. However, the broader questions of application and machines can be sufficiently discussed.

It will be of interest to briefly trace some of the developments and background of a-c welding in this country. World War I efforts, gave a tremendous impetus to arc welding and part of this impetus was in the direction of a-c welding. It did not last. This, it may be said, was chiefly due to the prevailing thinking on the use of bare electrode. Bare electrode, so-called, was not satisfactory for a-c welding. Hence without a great deal of attention directed to electrodes for a-c, engineers concentrated on developing better and better direct current single operator welders. Some attention was given to the lightly coated electrodes for a-c welding, but in general a-c welding had perhaps an undeserved bad reputation. It was considered a poor second for d-c welding. Relatively high open circuit (no-load voltages) were necessary to do any sort of a job with a-c welders even with the lightly coated electrodes, and the availability of these electrodes was extremely limited.

Following this came a period of intensive electrode development which directed attention to the possibilities of the combination of alternating current welders and coated electrodes. This directed more attention to the investigation of a-c welding and improvements in a-c welder designs.

Without discussing details, these investigations along with increasing applications of alternating current welding led to these conclusions:

1. With suitable electrodes, there was no difference in weld quality.
2. The operating efficiency under load, and the very low no-load losses presented opportunities for remarkable power savings.
3. The almost entire absence of arc blow greatly improved welding conditions and welding speeds, especially with high current welding on heavy sections.
4. The operating power factor was low and thereby represented an objectionable feature in certain cases.
5. There were some limits to the application because of lack of electrodes for certain classes of alloy steel welding.

Discussions of power factor and operating efficiencies will follow.

The relative absence of arc blow especially recommended a-c machines for work on heavy structures containing numerous short welds, angles or curves. Coincidentally large diameter electrodes of the coated type for flat and horizontal fillet work had been developed, which were capable of operating at high current densities. The elimination of arc blow permitted these electrodes to be used at their most favorable operating currents. Consequently the value of a-c welding on thick wall pressure vessels, heavy machinery construction and fired pressure vessels, became immediately apparent. These applications for a time concentrated the attention on the development of machines in ratings of 500 amperes and over.

Further developments in electrodes for lighter current welding recommended the use of a-c welders on the

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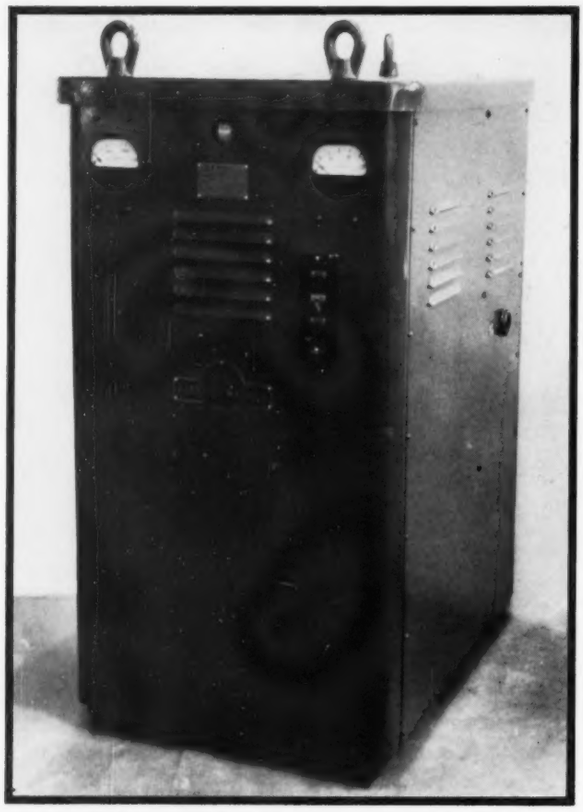


lighter jobs both in sheet metal work and in maintenance and repair work. Consequently the field of welding was actually extended downward, at first, to sections and jobs which had heretofore not been arc welded.

Rather naturally, two general classifications of a-c welders became broadly recognized — the machines used on heavy current welding, usually 300 amperes and over and rated on a one hour basis, and the smaller machines below 300 amperes, which were usually rated on a 30 minute basis. The same method of rating also prevailed on direct current welders.

All classes of carbon steel welding could be readily handled by electrodes available, cutting operations could be very well carried out, usually using a metal electrode in preference to a carbon, but certain alloys, could not readily be welded. This is not an inherent impossibility, it is just a question of the development not having been done. In the alloy field, all classes of hard surfacing can now be handled with commercially available electrode and the stainless steel welding situation on a-c, has been partially cleared up. There is no question but that a reasonable further amount of development on stainless steel electrode, would result in electrodes which would be adequate for the nickel chromium alloys.

During the rearmament period prior to December 7, many additional a-c welders were put into service on armament work. With the tremendous speed-up in war production, many additional applications of a-c welders are being made. This is to be expected because the background of machine development and electrode development was already completed. Machines are in general readily available, and as a part of the conservation program, the a-c welder is an extremely important element in the welding picture. Substantially lesser amounts of copper and iron are used in the construction of a-c welders than in d-c welders and this is an extremely important element. Manufacturing capacity of a-c welders has to date been able to meet the requirements, and with substantially lower amounts of critical materials, per ampere of welding output.

As to the disadvantages of a-c welders, pointed out, the low primary operating power factor, has without doubt been one of the most important. The effect of low power factor is to increase the amount of current or line kva for a given amount of heat energy. This loads up the distribution equipment and feeder circuits, causing additional power losses and increased voltage regulation. These factors are quite frequently overlooked or disregarded, but when it directly affects the power rate, as it does in many districts, serious consideration is usually given to the economics of low power factor. Power rates may penalize low power factor either directly, or in the form of maximum demand kva or reactive kva.

Figure 1 — (above) 300 ampere a-c welder with hand crank control and power factor correction.

Figure 2 — (left) Illustration showing construction of 300 ampere welder with cover removed.

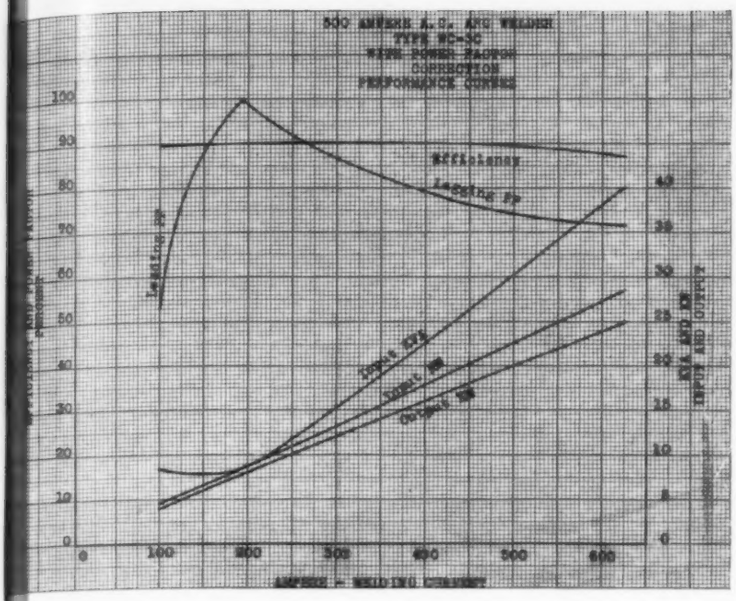


Figure 3 — (above) Typical performance charactistic of a 500 ampere transformer type a-c welder.

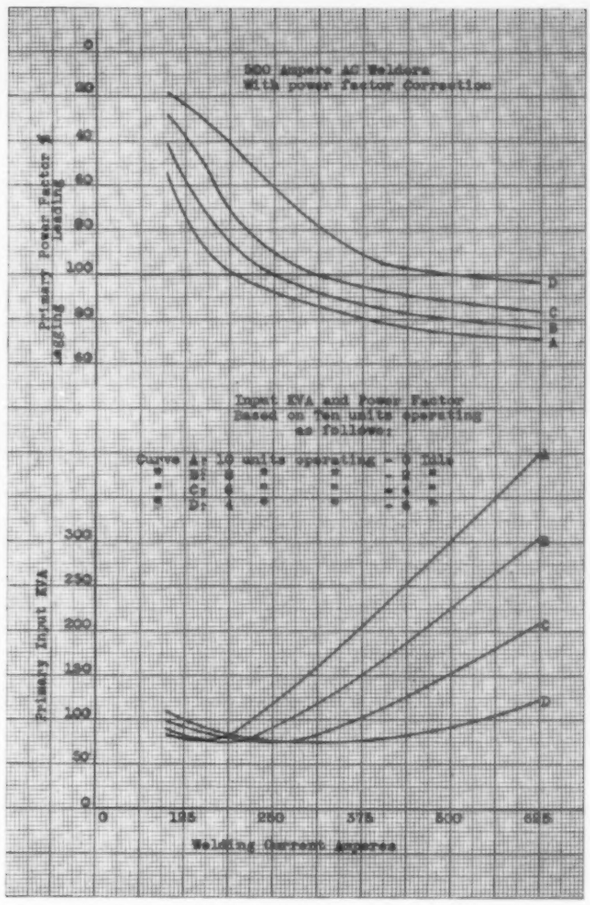


Figure 4 — (right) Curves illustrating power factor and kva input to a group of ten 500 ampere welders under various load conditions.

The power factor of a-c welders was very much improved in recent years as a result of lowering the open circuit secondary voltage, which was made possible by development of a-c electrode with suitable characteristics for use on alternating current. A-c welders of industrial ratings now have a power factor on the order of 50 to 55 per cent without any power factor correction. During the past year or two there has been a very definite trend toward the use of power factor corrected a-c welders, which has not only effected lower operating power costs, but has, in many instances, permitted additional welder load on existing shop circuits which would otherwise not have had sufficient capacity.

On the conventional high power factor welder, power factor correction is obtained by means of a capacitor integrally assembled as a part of the welder, and connected across the primary winding. Electrically, the result is the same as though the capacitor were connected on the primary line at some external point near the welder. The advantage of combining the capacitor with the welder is that the unit may be used on either of the dual primary voltage ratings, with the same degree of power factor correction. Combining the capacitor and welder permits using a capacitor of economical voltage rating, because the voltage applied on a capacitor can be economically transformed to the required capacitor voltage.

Typical performance characteristics of a 500 ampere transformer type a-c welder are shown on the curve, Figure 3. It will be noted that the power factor varies from 100 per cent at 200 amperes, to 74 per cent (lagging) at 500 amperes. Below 200 amperes the power factor is leading, and on open circuit secondary approximately 13 kva at 100 per cent leading power factor is drawn from the line. This leading kva is consumed so long as the welder is connected to the line, and on installations of only a few isolated units this capacitance kva may be desirable because it helps to correct the overall plant power factor.

On installations where a considerable number of units are involved, some consideration should be given to the probable overall power factor of the group. Owing to the fact that welders for manual welding operate intermittently at welding current values of between 20 to 125 per cent of normal rating, it is possible to obtain a wide range in overall power factor of a group of welders. Since excessive leading kva may be objectionable, the amount of corrective kva built into the welder should be based on average load conditions. This is best illustrated by the curve in Figure 4, which shows power factor and input kva to a group of ten 500 ampere welders operating under various load conditions. The amount of correction chosen is sufficient to give between 90 and 100 per cent power factor at average welding current values on a 60 per cent load factor, which corresponds to six units operating, and four idle.

The transformer type a-c welder has the advantage of much lower power consumption than the corresponding motor generator d-c welder. The saving in power is obtained as a result of much better electrical efficiency

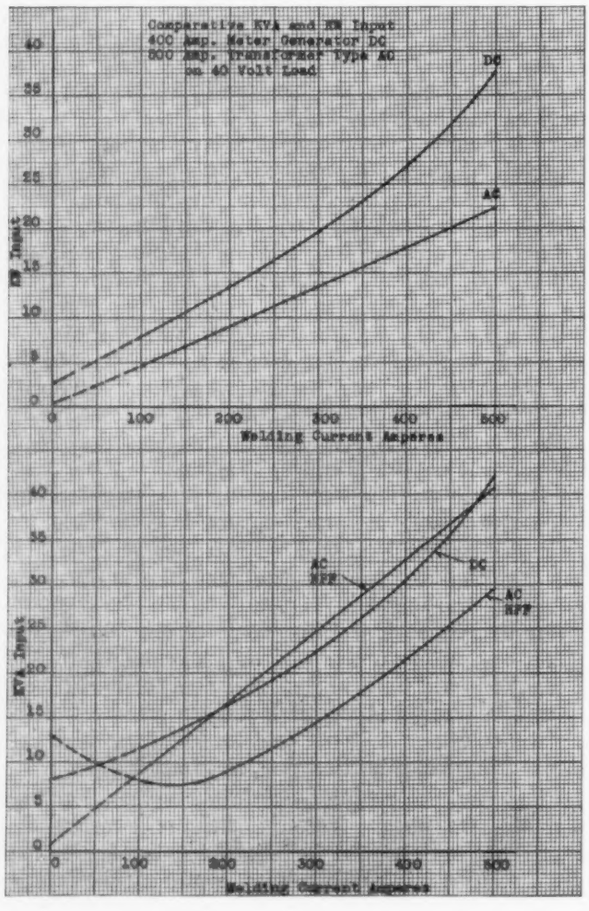
and lower idling loss. Figure 3 shows a comparison of kw and kva input, to typical designs of 400 ampere motor generator d-c set and a 500 ampere transformer type a-c welder. It will be noted that the kw input to the a-c welder is only approximately 65 per cent of that to the d-c machine under similar load conditions.

The idling loss of a transformer welder is on the order of one-fifth that of the d-c unit, and because of the fact that arc welders for manual welding are idling 50 per cent or more of the time, the difference in no load loss is an important factor in total power consumption.

The lower curves in Figure 5 show the kva input for the two types of welders. Under welding load the kva input for the normal power factor transformer type a-c welder is approximately the same as for the d-c machine. Because of the fact that the power factor of the d-c welder is already high, nothing can be done to decrease the demand kva. In the case of the a-c welder, however, the kva under load can be reduced by power factor correction, as shown by the curve for the high power factor a-c welder. With power factor correction the maximum demand of the a-c welder is reduced to about 70 per cent of that for the corresponding d-c machine.

A comparison of the no-load input, as shown on the curve for zero amperes, illustrates the further saving under this operating condition. The no-load kva of the high power factor a-c welder is higher than that for the d-c machine, but this kva is at practically 100 per cent leading power factor, which under normal conditions, is desirable because it provides power factor corrective kva for the other plant load.

Figure 5 — The curves compare the kw and kva input of a typical 400 ampere motor-generator d-c set and a 500 ampere a-c transformer type welder.



Estimates on overall power consumption based on 50 per cent load factor show a saving of approximately 35 per cent in kwhr consumption, and an additional reduction, (using high power factor a-c welders) of approximately 25 per cent maximum demand kva. These estimates have been substantiated by measurements on actual installations.

Transient characteristics are practically non-existent in connection with the transformer type a-c welder; consequently, there is no current and voltage "overshoot," or "time of recovery." Because of the fact that the welder is connected to a generator source of relatively large capacity, the generator characteristics do not influence the operating characteristics of the welder. The stabilizing reactance built into the transformer welder is instantaneous in action, as contrasted by that of a motor-generator set, which has a d-c field having a relatively high time constant, and resultant sluggishness to changes in current or voltage output. The question sometimes arises regarding current surge on the primary at time of striking the arc. The conventional transformer type a-c welder has a high internal inductive reactance, which is adjustable between certain limits corresponding to the welding current range. The amount of this reactance is necessarily of such a value as to definitely limit the maximum current obtainable on short circuit to between 10 and 15 per cent above the normal welding current value for which the welder is adjusted. This characteristic, therefore, eliminates the possibility of getting objectionable disturbances on the primary circuit due to excessive starting current, such as is characteristic of some types of apparatus.

The fact that the transformer type a-c welder represents a highly inductive circuit sometimes raises the question regarding the possibility of obtaining a higher than normal secondary voltage, due to collapse of the field in the reactor when breaking the arc. Such an "inductive kick" is sometimes experienced when direct current in an inductive circuit is interrupted. In the case of alternating current, however, the arc is extinguished at the point of current reversal, at which instant the current is zero and the stored energy in the inductive reactance is also zero. Consequently, no excessive voltage higher than the normal instantaneous open-circuit secondary voltage can appear at the terminals of the welder. These facts have been substantiated by numerous tests and oscillograms made in connection with circuit breaker tests and also arc welders.

Figure 6 shows an oscillogram record of primary and secondary current, and also primary and secondary voltage of a typical transformer type a-c arc welder with power factor correction. This oscillogram is a record of a complete cycle of operations starting from the time that the primary line breaker is closed, at the beginning of welding, continuing until welding ceases and the primary breaker is again opened. The initial primary current immediately after closing the breaker is that drawn by the capacitor. It will be noted that there are no excessive peak values of current or voltage

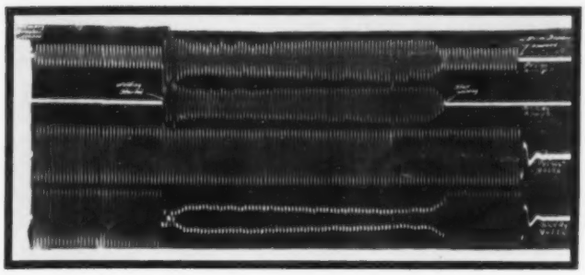


Figure 6 — Oscillogram record of primary and secondary current and primary and secondary voltage of a typical transformer type a-c welder with power factor correction.

either at the time of striking the arc, while welding, or at the time the welding arc is extinguished.

The oscillograph record just shown gives a picture of voltage conditions. The actual open circuit voltages — no load used will be of interest. The difference between the open circuit voltage, and the actual arc working voltage, represents a measure of the reactive drop and consequently the stability factor of the machine. With the older types of electrode, even the earlier types of coated electrode, open circuit voltages of 110 volts root-mean-square value were considered necessary. Subsequent developments in improving stabilized electrodes have led to a national standard of 80 volts maximum on machines for manual welding operations. It is found that 80 volts is sufficiently high to cover the heavy duty high current electrodes for flat and horizontal fillet work. For a time it was still customary to build these machines with a 100 volt tap which it was thought might be used on occasion. Even that has passed out without any serious interference with the welding operations.

On the smaller welders, where electrodes for all-position welding predominate, and where arc voltages are usually 30 volts or even in some cases less, it is found that satisfactory open circuit voltages may be as low as 50 volts. In fact the 50 volt open circuit operating point has come to be a test voltage for the performance of an a-c electrode in all classes excepting the flat or horizontal fillet electrode in the high current heavy duty class. These electrodes, having higher arc voltage, still require open circuit voltages on the order of 80 volts. The exception — rather contradictory — on the smaller welders is that for the very lowest current settings, 80 volts again becomes desirable. At these current settings, normally used with $\frac{1}{16}$ or $\frac{3}{32}$ inch electrode, it is found that the use of 80 volts is quite desirable as an aid to striking the arc, particularly if welding with alloy electrodes. In the diameters $\frac{1}{8}$ inch and over, 50 volts is found quite satisfactory on the electrodes having the lower arc voltages and generally used for all-position welding. These smaller machines are ordinarily used near the work, so the possibility of interference from line reactive drop in the secondary leads is not important.

Alternating current welding power as a source of welding supply for automatic welding has become very important during recent years.

A-c was used with bare automatic welders to a rather limited extent. It was never very successful with bare wires for the same reasons that it was not successful on manual welding with bare wire. Numerous installations were made with a-c welding power using lightly coated electrode. The machinery and equipment were satisfactory but again the limitation imposed by electrodes limited the application. Recent developments in electrode indicate further extensions in this field.

The outstanding success of alternating current welding power for automatic welding is found in connection with Unionmelt welding.

"Unionmelt" welding as developed by the Linde Air Products Company is an electric process using the heat generated by the passage of an electric current from an electrode to the work being welded. The end of the electrode is covered by a highly resistant conductive medium consisting of a granulated material known by the trademark "Unionmelt." The entire welding action takes place beneath this granulated material which is laid down along the seams to be welded.

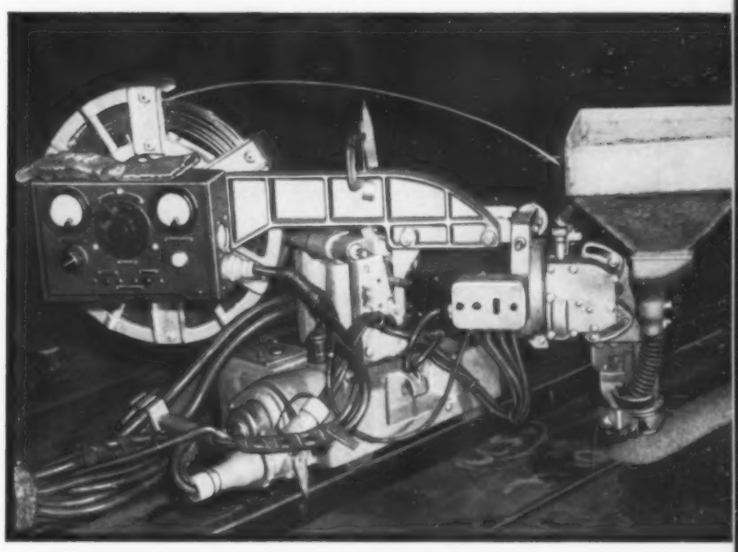


Figure 7 — Head used in welding by the Unionmelt process.

High currents are used as the process is generally applied to sections $\frac{1}{4}$ inch thickness or over, although that is not a limiting factor. Excellent weld quality and high welding speeds are obtained. Usually currents on the order of 800 to 1000 amperes are used on the smaller fillets. On some applications the currents may run up to 2000 or even 4000 amperes.

A-c welders are readily adapted for building in large capacities. The absence of arc blow from a-c welding power, and the high operating efficiency of the welder have established alternating current as the preferred type of power for "Unionmelt" welding. An additional feature of importance, is the ease of control of welding power. The use of contactors in the primary circuit of the welder provides for conveniently and quickly cutting power off the entire system, when welding stops. When welding is resumed the entire system is energized from

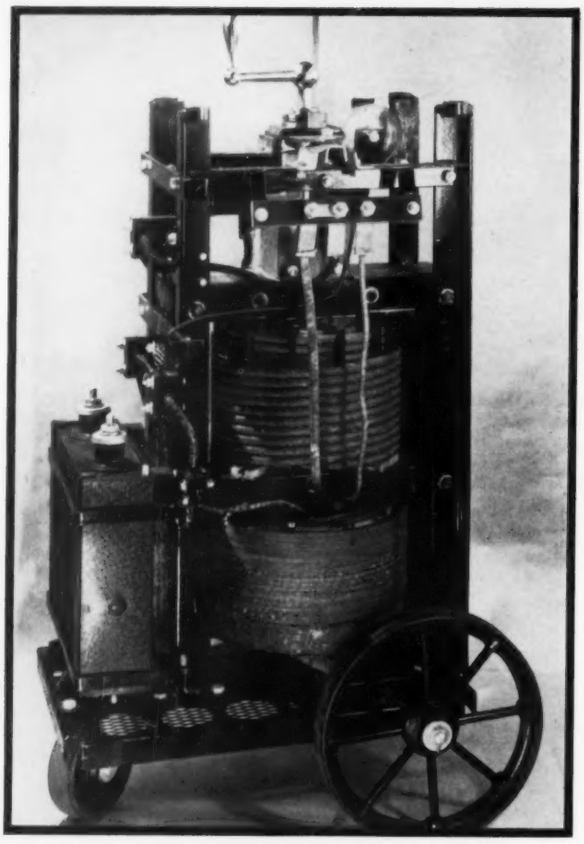


Figure 8 — Interior view of the 1000 ampere welder showing control panel, capacitors and control transformer incorporated with the welder.

one push button station which re-established the primary power.

Units of 1000 amperes, may easily be used in multiple to obtain larger capacity, or in some cases, units as large as 1500 or 2000 amperes are regularly used.

A discussion of a-c welders would not be complete without some reference to safe operating practices. There is usually the tendency to point out some recorded number of accidents with a-c welders and draw conclusions based upon such figures. There have been fatal accidents on direct current welders, and while records are never complete, the percentage of accidents of the number of d-c machines in use is small when compared with the percentage on the a-c welders in use. Conclusions based on percentages only are apt to be misleading. Up to the beginning of the intensive armament program, it is estimated that there were approximately 20,000 a-c welders below 300 amperes in use. This figure excludes the low price low voltage a-c welders. It is known that many of these welders have open circuit voltages higher than 100 volts because they were built before the Underwriters' limited the open circuit voltage to 100 volts. Accident reports have not come to our attention on any of these machines. It is possible that accidents have happened, but they are not known. This leads to the conclusion that these welders are generally used under very favorable conditions with operators not working very hard or not working under much of a strain.

The reported accidents mainly come from machines used on heavy production work. This is also true of d-c machines. These accidents mainly occur in hot weather when the operator is working in confined spaces where there is more likelihood of physical contact with the work. Some brief and pointed recommendations for safe operating practice are given as follows:

Precautions should especially be taken to avoid electrical shock. Voltages required for arc welding are low and normally will not cause injury nor severe shock and so parts having these voltages are liable to be handled carelessly. These voltages are, nevertheless, sufficiently high that under certain circumstances they may be dangerous to life. This danger is particularly marked in very hot weather, when the operator is sweaty or wet. The operator should develop the habit of always keeping his body insulated from both the work and the metal electrode and holder. He should particularly never permit the metal part of an electrode of the electrode holder to touch either his bare skin or touch any wet covering on his body. Consistent use of insulated electrode holders, well insulated cables, dry protective coverings on the hands and body, and insulation from ground will be helpful in avoiding contact.

It should never be assumed that because contact with the electrode at one time is not harmful that similar contacts at other times will be similarly harmless. Changes that are not noticeable can take place in conditions which could change the effects of contact.

There has been no attempt to detail specific welding operations as applied to any industry. The a-c welding is successfully stepping into all types and classes of welding application required in maintenance and repair, and in fabricating all types of armament. True, there yet remains some limitation, especially in the welding of non-ferrous metals, but those are not such as to definitely limit the use of the machines. Urgent war time needs have emphasized the value of a-c welders, and the a-c welders are doing their part and saving power and critical materials.

DISCUSSION

PRESENTED BY

WRAY DUDLEY, Assistant Superintendent of Maintenance, National Tube Company, McKeesport, Pennsylvania

EMIL STEINERT, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

W. E. DORSCHEL, Pullman Standard Car Manufacturing Company, Hammond, Indiana

M. M. MacDONALD, Electrical Superintendent, Andrews Steel Company, Newport, Kentucky

W. W. REDDIE, Manager, Welding Sales, Motor Division, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

J. H. COOPER, Chief Application Engineer, Taylor-Winfield Corporation, Warren, Ohio

C. H. JENNINGS, Research Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

WRAY DUDLEY: I have frequently pondered over the problem as to why we ever started with direct current for this job and have reached the conclusion it was the type of current with which the men first concerned with its application to welding were most familiar. Like many other applications of electricity, as we became more familiar with the problem and knew better how to handle it, we gradually turn to a-c where the ultimate lies in simplicity, in cost and usefulness, and I think the case presented here in this paper will certainly go a long way toward encouraging the greater use of a-c welding.

Steel men, of course, are still largely involved in 25 cycle. I would like to ask if it is practical to apply power factor correction to 25 cycle welders.

EMIL STEINERT: It is entirely feasible to correct the power factor on the 25 cycle welder by the same means that it is done on the 60 cycle, except that the cost is considerably greater. For instance, a 15 kva capacitor which is ordinarily used in a 500 ampere 60 cycle welder would have only 25/60ths of the kva on 25 cycles, and the cost of additional capacity would, for that reason, be considerably higher.

W. E. DORSCHEL: The speaker remarked that there were certain dangers inherent if you went too far on the power factor correction, on the leading side. I would like to know what those dangers are. When down to no load, or practically no load, you were practically 100 per cent leading. In other words, if you put too much reactive kva in there, you got into trouble. I would like to know what those troubles would be.

EMIL STEINERT: The only objection to the high leading power factor is that it causes additional line loss under no load conditions, and the effect of the low leading power factor is to raise the voltage at the end of the line, at which point the capacitor is connected. This may be objectionable if the line is too small for the capacitor, but that would generally not be true because the amount of kva drawn by a welder under no load conditions is very much smaller, approximately one-fourth or less than it is under rated load. The only objection that I could see exists due to the fact that you have the additional losses in the lines and the distribution equipment, due to the current which is drawn by the capacitors.

M. M. MACDONALD: I have in mind a question that is off the subject but it is of interest to all of us. Does that same problem exist in a-c welding that confronts us daily in d-c welding — improper or high resistance connections of welder ground leads that cause burn-outs of cable and conduits? We are troubled with this problem in a number of old plants and also new plants in which the building columns and equipment are not tied together and adequately grounded the welding ground return is carried by a cable or conduit not intended for this purpose. Has this same trouble been experienced with a-c welding?

EMIL STEINERT: That sometimes occurs on certain welders which have one of the secondary terminals, usually the work terminal of the secondary, connected to the frame of the welder, and then in addition to that, a third ground lead in the primary circuit for grounding the welder frame. If the work lead, that is the connection from the work terminal on the welder to the job which is being welded, becomes open or there is a high resistance connection, the welding current will flow through the ground and through the primary third conductor which does not have sufficient capacity to carry that much current, causing a burn-out in the primary cable. This trouble can be readily overcome by disconnecting the connection from the work terminal of the welder to the frame of the welder. In our particular case, we do not connect either of the secondary terminals to the welder frame.

M. M. MACDONALD: If that were done, would that not constitute a rather serious hazard?

EMIL STEINERT: No, it does not. The frame of the welder is grounded through the third conductor of the primary circuit or directly from the frame of the welder to a ground connection, and the secondary winding is isolated from the primary.

WRAY DUDLEY: Reference was made to some doubt as to the practicability of using these machines for outside welding on steel buildings being erected. Would you tell us what those anticipated difficulties were?

W. W. REDDIE: I didn't want to throw any doubt in the mind of anyone, but if we go back, it is a question of machine failure; that is what it amounts to. If we go back to d-c motor generators, the manufacturers of d-c motor generators by definition, practice, standards and everything else, designed machines for what we call indoor service. If somebody wanted to use them out in the weather, he put a canopy over them, built a little tent around them or a housing of some kind. Then over a period of time, practically everybody who built d-c welders gradually closed them up more and more, and they were defined as drip-proof, but were never called weatherproof. We call them drip-proof, just as we call a-c welders drip-proof.

Users gradually took liberties with the d-c machines and you see many machines now outdoors without any of these tents or housings around them, and every so often someone loses a machines, especially after a storm, and little or no attention is paid to it. You fix it up and go along.

Due to our tremendously accelerated shipbuilding program, there are hundreds of d-c welders that are used outdoors with little or no protection. Other concerns who are more conservative do protect them. As I say, it is habit and practice. It is done. Nobody objects and if the user loses his machine, he repairs it. He prefers to do it that way rather than be bothered with housings.

Now we don't have that much experience on a-c welders. A-c welders as such are generally thoroughly enclosed. We would call them drip-proof. We don't call them weatherproof. In our own case, we have used a number of machines outside with no protection except to have tarpaulins thrown over them at night, and my reference is to whether, as we go along, we can leave those machines out in the weather. We have had certain machines that I know have been out since last spring with no protection whatever and they seem to be getting along all right. Whether they will go through the winter that way or not, we don't know. If you set out, of course, to make a weatherproof machine, you put more money into it.

If we have the same experience that we have had on d-c machines — and I rather think we will have — we

(*Please turn to page 71*)

Gauge Control IN COLD ROLLING *Strip* MILL

. . . . test on various electrical methods for maintaining gauge in the cold rolling of strip steel show that a marked decrease in the off-gauge material can be made . . . .

by J. D. Campbell

INDUSTRIAL ENGINEERING DIVISION

GENERAL ELECTRIC COMPANY

SCHENECTADY, NEW YORK

▲ Certainly in these times of steel shortages, steel scrap deficiencies, electric power restrictions, and other items, the subject of gauge control should not be left to peacetime discussions. Our vital need for more steel to win the war has added a powerful incentive to the reduction of "off-gauge" losses. In addition, good business practice in cold rolling operations dictates that the per cent finished strip that is too thick be kept at an economic minimum. Every per cent reduction in off-gauge materials shows direct benefits. The writer has found that cold mill superintendents are acutely aware of this, and they will become interested immediately if anyone has a new idea for reducing off-gauge. The superintendent will again and again push his other work aside to talk "off-gauge reduction." In these days of war, there is one additional motive in reducing the per cent off-gauge in cold rolled strip. If a tin plate cold mill is able to reduce its off-gauge from 3 per cent to 1 per cent, its total scrap loss will be reduced by about the same amount. Over a year's period, this means 2 per cent reduction in material and labor losses, or about one week of operating practice.

Spoilage losses in any industry become increasingly important when the product nears its completed stage. For example, let us compare the losses in hot strip rolling operations with those in cold rolling of steel. In the first case, if the scrap losses per ton are reduced by 10 per cent, there is a very definite gain in labor, material, and dollar savings. If, during cold rolling, the off-gauge is also decreased by 10 per cent, the resulting savings may be 140 per cent of those in the first case.

From a monetary viewpoint, let us see what savings result when off-gauge is reduced from 3 per cent to 1 per cent. A modern tin plate mill can easily average 300 tons of finished steel in an 8-hour shift. Running at present schedules, 50 shifts a month is common. If off-gauge is reduced from 3 per cent to 1 per cent, this is a saving of 300 tons per month. Considering the current prices of finished cold-strip and the scrap value of off-gauge strip, the off-gauge loss will be approximately $40 a ton or $12,000 per month. Or, in summary, for each 1 per cent reduction in off-gauge, there is a monthly saving of $6,000. No wonder the cold mill superintedent is ready to "talk business" if something can be added to his mill that will reduce the scrap losses.

This paper will be confined to electric means of reducing the amount of scrap loss in steel strip due to off-gauge finished material. More specifically, it will be concerned with the rolling of tin plate strip in tandem cold mills, similar to that shown in Figure 1. However, the general principles will naturally apply to all types of tandem cold strip mill procedures. Throughout this discussion there will be the tacit assumption that electric means of gauge control is just one of several methods, and that other non-electrical means are just as much in the picture. For example, the assumption will be made that the cold mill operating crews have set up the mill in such a way that the drafting is right for each stand, that the roll shape is proper, that the coolant solution is in the right condition, that the coolant is applied properly, that the incoming strip fed to the mill is practically all "on-gauge," and that large coils of

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strip are used. Other non-electrical means, important to off-gauge reduction, are known and their importance can be very great.

Looking then, at the electric generators, motors and control, what can the electric equipment manufacturer do to help the cold mill operator reduce his off-gauge? In September, 1939, F. Mohler delivered a paper at the convention of the Association of Iron and Steel Engineers. Its subject was "Gauge Control for Cold Strip Mills," and it clearly pointed out where gauge control fitted into the electrical user's and manufacturer's departments. "Gauge-getting" or "gauge-keeping" was discussed broadly during all periods of mill operation. Here, however, gauge-getting or keeping will be associated only with the mill accelerating periods or decelerating periods. Further, where gauge may be electrically controlled by means of roll (or screw) position and strip tension, only the latter means will be considered. Of course, the mill operators can manually control, say, tension between stands by changing one or more of the mill motor speeds; but electric gauge control includes automatic means whereby the operator's job is lightened or the automatic control gets better results, generally, than does the operator.

Referring once more to F. Mohler's paper, it was there pointed out that gauge control could be accomplished during the mill accelerating and decelerating periods by tension control. Tension control could be by two general means, both means affecting the mill motor speeds. The first method is by automatic control of the shunt field strength of each mill motor, broadly called "tapered tension control by motor field adjustment." The second is by an independent control of motor armature voltage over a limited range by series booster generators, broadly called "IR drop compensating boosters." By expanding on the second method, we can further control the booster voltage in such a way that we obtain "tapered tension control by booster generators."

In this paper no new principles of gauge control by "tapered tension" or "IR drop compensating boosters" will be brought out. Instead, the principles will be reviewed for completeness only. Results of test, using magnetic, multi-element oscillographs during cold rolling operations, will be shown. The two broad methods of gauge control will be compared as to their relative "gauge-getting" or "gauge-keeping" effectiveness. Finally, the economics of where to use one method and where to use the other will be considered.

GENERAL CONSIDERATIONS

In tandem tin plate mills of the recent high-speed type, the hot-rolled strip coil is threaded into the cold mill at a speed of 100 to 600 fpm. During or after the threading of the delivery tension reel, the mill is accelerated to a top speed, which may be as high as 4000 fpm. After rolling most of the coil at top speed, the mill is decelerated to threading speed as the rear end of the strip is approached. Using typical figures, it is gauge control during the transient period from 600 to, say 3000 fpm and from 3000 down to 600 fpm that we are interested in. Somewhere in these ranges the finished strip thickness goes beyond the tolerance limits and is

Figure 1 — In the high-speed tandem tin plate mills, the wide speed variation between running and threading sets up a problem in maintaining strip gauge.

called "off-gauge." The allowable tolerance will, of course, depend on the material, gauge, and the end use.

Invariably the gauge will be rolled "heavy" at the lower operating speeds, if no attempt is made to manually or automatically hold gauge. If the mill motor speeds are changed in such a way as to increase the strip tensions between stands, "on-gauge" may be obtained (or held) at lower operating speeds. Just why the gauge goes heavy at or near threading speeds is not completely understood; but electric means of motor control can compensates for the effect in spite of this obscure cause.

Figure 2 gives an example of how much off-gauge can result from three different operating methods. The mill considered is a conventional tandem mill with shunt motors operated by adjustable voltage control. In method A the strip is threaded on the delivery reel until several wraps are "caught"; as the mill is quickly accelerated to top speed, "gauge" is obtained at, say 1500 fpm and held until the mill is subsequently decelerated to 500 fpm. (Actually "on-gauge" can usually be held on deceleration down to 700 or 800 fpm). Method A results in off-gauge material amounting to about 59 feet of finished strip during acceleration. If we assume an equal amount of off-gauge on deceleration and assuming large coils of finished strip to be 10,000 feet in length, the off-gauge amounts to 108 feet or about 1.1 per cent. The shaded areas in Figure 2 are proportional to the amount of off-gauge during acceleration.

Let us further assume that quick acceleration to top speed cannot be accomplished in 6 seconds, as in the first example. In method B (Figure 2) the mill will accelerate in a longer time, but gauge will be obtained at about the same speed. Here the off-gauge on acceleration amounts to about 86 feet or roughly 16 wraps on the delivery tension reel.

In method C the operators quickly accelerate from threading to 1000 fpm where the mill is "leveled off" in

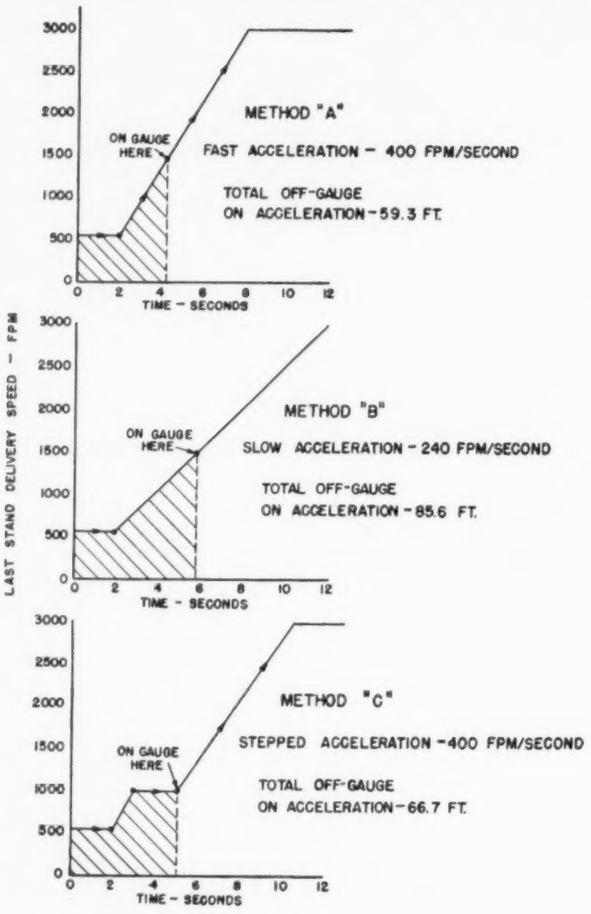

LAST STAND DELIVERY SPEED - FPM
METHOD "A"
ON GAUGE HERE
FAST ACCELERATION - 400 FPM/SECOND
TOTAL OFF-GAUGE ON ACCELERATION - 59.3 FT.
METHOD "B"
ON GAUGE HERE
SLOW ACCELERATION - 240 FPM/SECOND
TOTAL OFF-GAUGE ON ACCELERATION - 85.6 FT.
METHOD "C"
ON GAUGE HERE
STEPPED ACCELERATION - 400 FPM/SECOND
TOTAL OFF-GAUGE ON ACCELERATION - 66.7 FT.
TIME - SECONDS

Figure 2 — Three common methods of getting gauge on acceleration in tandem mill rolling after threading the tension reel.

speed long enough for the operators to adjust the strip tensions and get gauge. After obtaining gauge at 1000 fpm, the mill is rapidly accelerated to 3000 fpm, holding gauge all the way up. About 67 feet of off-gauge is lost by this method on acceleration only.

Evidently, as has long been realized, quick acceleration and deceleration is one extremely effective method of getting off-gauge reductions. But the economic limit of rapid acceleration and deceleration has been practically reached. At present one tandem mill is accelerating from threading speed to 3800 fpm in 6 seconds. It can be stopped from there in 5 seconds. Actually, only 160 feet of finished strip are delivered from the mill during this quick-stopping period. This is similar to stopping a motor car from 43 miles an hour in 160 feet.

The subject of fast acceleration is not out of place in this paper because, as will be shown, IR compensating booster generators definitely enable the tandem mill to accelerate or decelerate more rapidly in unison. Fortunately, they also give a more direct means of quick "gauge-getting" on acceleration, or long "gauge-holding" on deceleration. This will be brought out later.

LOSS OF SPEED CORRESPONDENCE BETWEEN MILL MOTORS

During the past ten years many tandem mills have been installed, using adjustable voltage control. The motors used to drive the mill stands were shunt motors with pole face or compensating windings. Their speed regulation throughout a two to one speed range was about 1 per cent to 4 per cent, drooping in speed from no load to full load. Like all shunt wound motors which are separately excited, their respective speed regulations were a combination of two effects. As the armature current varied with load, armature reaction tended to distort and to change the main field flux. Secondly, the armature current changed the internal resistance drop in the armature circuit. The first effect (armature reaction) could be reduced by compensating windings, while the second effect (IR drop) could not be eliminated in the design of the motor itself. The first effect tended to raise the speed on increased load; the second would decrease the speed on increased load.

In recent years it has been possible to design compensating windings which are almost 100 per cent effective. In other words, the speed regulation of the motor would be entirely dependent on the IR drop in the armature circuit. Where the design of the compensating windings fell short of 100 per cent compensation, special shunt fields with series characteristics have been added to give almost the same effect as 100 per cent compensation. Nevertheless, a motor with 100 per cent compensation and 4 per cent armature circuit resistance will have at rated voltage a speed regulation of 4 per cent, drooping from no load to full load. This 4 per cent regulation will be the same regardless of the full shunt field strength. Of course, if the motor is operated below rated voltage, its per cent speed regulation will vary inversely with the voltage. Thus, at full voltage, the speed regulation will be 4 per cent; at half voltage on the armature it will be 8 per cent.

Keeping the afore-given facts in mind, let us refer to the top portion of Figure 3. Here two motors are operated from a common generator. Irrespective of the types of loads on them, they will not always maintain their speed relationships if their relative loads vary. In other words, if their ratio of speeds are 60:100 when operating at 100 per cent bus voltage and 100 per cent load on each, the speed ratio will no longer be 60:100 when their percentage loads differ.

In tandem mill operation, the percentage armature currents will differ between the motors during acceleration and deceleration. Only two stands of a tandem mill are shown, for simplicity, in Figure 3. If the mill speeds are in correspondence (ratio of the roll surface speeds 60:100) at 100 per cent load and 100 per cent armature voltage, the correspondence is lost to the extent of 69:100 when accelerating with the same shunt field settings from threading speed. Similarly, when decelerating from top speed to threading speed, the correspondence is lost to the extent of 54:100.

What have the curves of Figure 3 to do with gauge control? As is well known, for a given uniform flow of constant-width strip through the mill, the thickness of the strip from a mill will vary almost inversely as the roll surface speed. Other factors such as screw position

and tension will affect strip thickness, but for a given set up of the mill, this rule is quite accurate. If this be true, then for the assumed values of armature currents given in Figure 3, the gauge (t_2) will tend to go from "heavy" to "on-gauge" as the mill is accelerated; it will tend to go from "on-gauge" to "light" as the mill is decelerated. This is a tendency which we can partially attribute to the loss of speed correspondence between stands 1 and 2.

To what extent are the curves in Figure 3 of practical value? First of all, the assumption of 100 per cent compensation in each motor is practical, particularly at low bus voltages, where the effect of any armature reaction is considerably less than that of the armature resistance drop. Secondly, the armature currents assumed may vary radically, but the tendency to lose speed correspondence is still evident. Lastly, the curves help to explain the tendency for the loss of correspondence to be greater during acceleration; this is just one of the many tendencies making it harder to get gauge on acceleration than to keep gauge during deceleration.

Figure 3 also helps us explain the known fact that if speed correspondence is held constant, the finishing gauge will tend to stay constant, if the incoming gauge (t_0) is constant. Thus, if the gauge goes "heavy" at any time, the tension between stands will increase, tending to bring the thickness down again. Again, if the gauge gets too light, the tensions will decrease and the thickness will increase. Thus, any means of holding speed correspondence between all stands of a tandem mill will enable the mill to "sense" gauge. It will "sense" gauge by an indirect means of speed relationship, and will "sense" gauge almost as accurately as will a flying micrometer which measures strip thickness directly. If the gauge goes "off," the constant speed correspondence will tend to decrease (or increase) tensions only to the point where gauge is obtained, and no further.

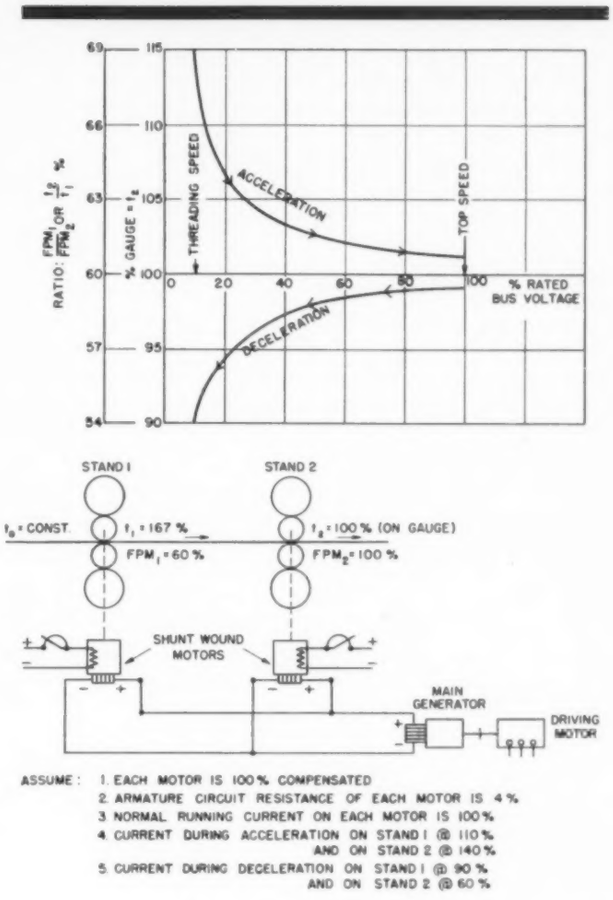
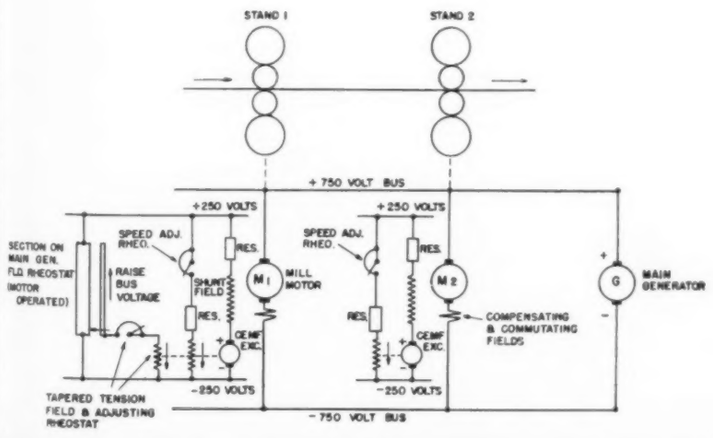

RATIO: FPM1/FPM2 OR t2/t1 %
% GAUGE = t2
THREADING SPEED
ACCELERATION
TOP SPEED
DECELERATION
% RATED BUS VOLTAGE
STAND 1
STAND 2
t0 = CONST.
t1 = 167 %
t2 = 100 % (ON GAUGE)
FPM1 = 60 %
FPM2 = 100 %
SHUNT WOUND MOTORS
MAIN GENERATOR
DRIVING MOTOR
ASSUME: 1. EACH MOTOR IS 100 % COMPENSATED
2. ARMATURE CIRCUIT RESISTANCE OF EACH MOTOR IS 4 %
3. NORMAL RUNNING CURRENT ON EACH MOTOR IS 100 %
4. CURRENT DURING ACCELERATION ON STAND 1 @ 110 %
AND ON STAND 2 @ 140 %
5. CURRENT DURING DECELERATION ON STAND 1 @ 90 %
AND ON STAND 2 @ 60 %

Figure 3 — Curve showing loss of speed correspondence between tandem mill motors during acceleration and deceleration.

Figure 4 — Diagram showing scheme of tapering tension by field control on one stand motor.



TAPERED TENSION CONTROL BY MOTOR FIELD

Disregarding the cause of heavy strip-thickness at low operating speeds, let us briefly consider gauge control by the first method. Figure 4 shows in elementary form how the strip tensions may automatically be varied between the first two stands of a tandem mill. Conventional shunt motors connected to a common variable voltage bus are shown. Each stand can be adjusted in speed by the speed adjusting rheostat, working on the main field of a cemf exciter. Any automatic control of tension is then accomplished by excitation of the tapered tension or auxiliary field of the cemf exciter.

If the speed adjusting rheostats of both stands of Figure 4 are set at the proper value when the mill is up to running speed, all tapered tension control can then be on stand No. 1 motor field. Referring to the cemf exciter on stand No. 1, if we excite the auxiliary field from a potentiometer circuit formed by a dial section on the main generator field rheostat, we can get cemf auxiliary field excitation which is a function of bus voltage.

At low speeds (low bus voltage) on the mill, if we strengthen the field of stand No. 1 motor through its cemf exciter, we will slow down stand No. 1 and hence increase the tension between stands No. 1 and 2. As the bus voltage reaches its peak value, the cemf exciter will weaken the motor No. 1 shunt field to its normal running value. Tensions will then be normal at running speed. On deceleration, motor No. 1 field will again be strengthened, slowing it down and finally increasing the strip tension between stands.

Obviously, tapered tension may be applied between any two stands of the tandem mill. For example, if we keep stand No. 2 as the "anchor" or "pivot" stand, we can increase the tension by slowing down stand No. 1 with respect to stand No. 2. Similarly, we can increase tension between stands No. 2 and 3 by speeding up stand No. 3, relatively.

On a 5-stand tandem mill, the complete control of tapered tension could be accomplished by using stand No. 4 as the pivot stand. Then tension at low speeds could be increased all the way along by automatically strengthening the motor fields of stands No. 1, 2 and 3. This would give us a "pulling back" on stand No. 4. At the same time, we could "pull forward" on stand No. 4, by weakening the shunt field of stand No. 5 motor.

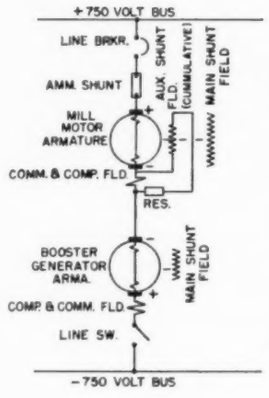
There is a limit to how far the motor fields may be weakened or strengthened during the tapering process. In the last example, the motor field on stand No. 1 would have to be strengthened, the greatest amount, in order to "keep up" with the field strengthening on stands No. 2 and 3. Usually, tapered tension set-ups can be more easily made by controlling tension only between the first two or three stands.

The magnitude of the tapered tension can be controlled by the tapered tension adjusting rheostat shown in Figure 4. The slope or the rate of tapering the tension can be determined by the layout of the motor driven rheostat resistance steps. For example, it is not necessarily true that the taper should be linear, or all the way to top bus voltage. In fact, a complete taper is usually not required. A truncated tapering of tension is often desired; for after gauge is obtained below half bus voltage, no further tapering is required above half voltage.

IR DROP COMPENSATION BOOSTERS

Previous papers delivered before the Association of Iron and Steel Engineers clearly pointed out the dual role played by mill motor series boosters. Firstly, by compensating for armature circuit resistance drop, they enabled all motors on the tandem mill to quickly accelerate and decelerate uniformly. Uniform acceleration and deceleration meant that no strip breakages or loops would result because of high tension or lack of tension. Quick acceleration and deceleration meant a reduction in the off-gauge strip. Secondly, the boosters could be used to maintain a constant speed correspondence between all stands, resulting in the tendency to hold gauge at all speeds — assuming, as always, a uniform incoming strip to stand No. 1.

Immediately, one will question the need for boosters from the standpoint of quick mill acceleration. This question is pertinent, for several reasons. With proper design of the motors, quick mill acceleration is usually as satisfactory as when IR compensation boosters are used. A tandem mill now in operation was accelerated both with and without IR boosters, with no pronounced difference in the uniformity of mill speed correspondence. Furthermore, uniform acceleration is not wanted, as was pointed out in previous paragraphs. In fact, the mill speed correspondence with tapered tension control is purposely upset. The answer, therefore, more and more points in the direction of boosters being primarily used for gauge control. IR booster control differs from tapered tension control in that it tapers tension more nearly automatically and requires no previous settings of tapered tension rheostats. With high values of IR drop compensation, the motors more nearly "sense" gauge and hence more accurately taper the tensions as needed.



MOTOR	VOLTS HOT DROP		% DROP % OF 750 VOLTS	
ARMATURE	14.4		1.92	
COMM. & COMP. FIELDS	11.3		1.51	
BRUSH DROP	2.0		0.267	
		27.7		3.69
EXTERNAL PARTS				
CABLE, BREAKER, LINE Sw, ETC.	0.8		0.11	
		0.8		0.11
BOOSTER				
ARMATURE	0.94		0.125	
COMM. & COMP. FIELDS	0.66		0.088	
BRUSH DROP	2.0		0.267	
		3.6		0.48
TOTAL IR DROP AT RATED CURRENT		32.1 VOLTS		4.28%

Figure 5 — Voltage drop distribution in a 2500 hp, 175-350 rpm motor and a 100 kw IR drop booster generator on a tandem cold mill. Armature current at 100 per cent rating.

Figure 5 shows the armature circuit of a mill motor, with its series booster, connected across the adjustable voltage bus. The resistance drop can be divided up into three parts: motor, external connections, and booster generator. The booster generator will compensate for the IR drop in the motor and the external connections. The IR drop in the booster itself will be taken care of by the booster. As shown in Figure 5, with rated motor armature current, the generated voltage in the booster will have to be 27.7 volts for the motor, 0.8 volts for external parts, and 3.6 volts for the booster; making a total booster voltage of 32.1 volts. At half this armature current the booster voltage will be half as great, so that booster voltage is thus strictly proportional to armature current.

Figure 5 is for 100 per cent IR drop compensation. By this is meant that for every volt of IR drop in the circuit between the main buses, the booster will generate one volt to cancel or compensate for the drop. Of course, the direction of booster volts is always opposite to that of the IR drop of 32.1 volts. Since the booster

is self-compensating for IR drop, we will consider only the motor and external parts IR drops which total 27.7 plus 0.8 or 28.5 volts. This last figure is 3.8 per cent of 750 volts and corresponds to 100 per cent compensation. With such a setting the motor cemf will always be exactly equal to bus voltage, and the motor speed will, therefore, correspond precisely to bus voltage.

Since series boosters are to give a voltage proportional to armature current, one would think that the natural type of booster to use would be one with series fields or with shunt fields excited by the drop across the booster compensating and commutating fields. The series field has the disadvantage in not being easily adjusted. The shunt field method can be too slow in getting rapid changes in booster voltage; for it is important that the booster voltage be not only proportional to armature current, but practically in phase with it.

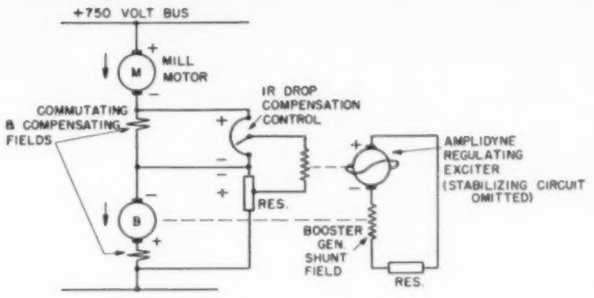


Figure 6 — Diagram showing scheme of amplidyne control on each stand motor booster generator.

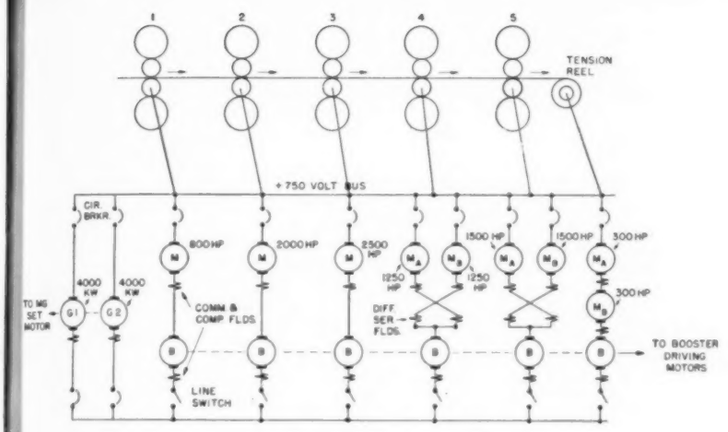


Figure 7 — Arrangement of booster generators for IR drop compensation on a tandem cold rolling mill.

Snappy booster control has been accomplished through amplidyne control of the booster shunt field. The simplified circuit is shown in Figure 6. The amplidyne and its associated circuits gives a speedy operation of the boosters through automatic "forcing" without attendant instability. Figure 7 shows the complete booster armature circuit arrangement in a tandem mill recently installed.

Reference to Figure 8 and Table I helps explain how the IR compensation boosters can give us close speed correspondence between tandem mill motors by virtue of their practically flat speed regulation characteristics. The data for stand No. 3 motor is included in both Figure 8 and Table I for illustrative purposes only.

Curve A of Figure 8 shows the speed regulation curves at base and top speed as plotted from test records. In curve A the motor is operated as a shunt machine with compensating windings, so that the speed regulation curves come moderately close to being flat. What is very important is the fact that the characteristics are practically straight lines.

The next step (curve B, Figure 8) is to connect up a small auxiliary shunt field on the motor which is excited from the drop across the commutating and compensating fields. The auxiliary field is connected cumulatively, giving the motor more droop in speed, compared with curve A. Adjustment of the field is made with two objectives; first, to make the per cent speed regulation at base speed about equal to that of top speed; second, to make the per cent speed regulation about equal to the per cent IR drop in the motor armature circuit. Curve B is shown with two conditions of field strength. The drooping speed regulation curves are without any IR drop compensation, and the speed regulation is then approximately 3.7 per cent at either base or top speed. Referring to Figure 8B, the per cent IR drop in the motor circuit is 3.7 per cent. Therefore if 100 per cent compensation (3.7 per cent IR drop) is used, the dropping speed curves will flatten out, as shown on curve B for 100 per cent compensation. At intermediate settings of speed between base and top speed, the regulation curves will still be essentially flat.

As the bus voltage on the motor is lowered to, say, 20 per cent or 150 volts, the per cent speed regulation at zero compensation will be about 18.5 per cent. Therefore, with 100 per cent compensation, the speed regulation will be flat as shown in curve C, Figure 8.

Table I shows some actual data on tandem mill motors which were installed over a year ago. As indicated in column 4, the speed regulations of all motors were adjusted for about the same values at base and top speed. These regulations average around 4 per cent. Column 5 gives the per cent IR drop in the motor circuits, which also average about 4 per cent. Therefore, generally speaking, 100 per cent compensation on all the motors will give them almost flat speed regulation curves. To prevent any rising speed characteristics in a motor with 100 per cent compensation, the compensation may be adjusted below 100 per cent. For example, stand No. 2 motor of Table I had a speed regulation of 4.2 per cent at base speed; the per cent IR drop is 4.4 per cent. Therefore, at 100 per cent compensation, the motor would tend to rise in speed by 0.2 per cent from no load to full load. Prevention of this is by operating at a per cent IR drop of 4.2 per cent or 95 per cent compensztion. Thus in column 6 the maximum "safe" adjustment of IR compensation is equal to the minimum

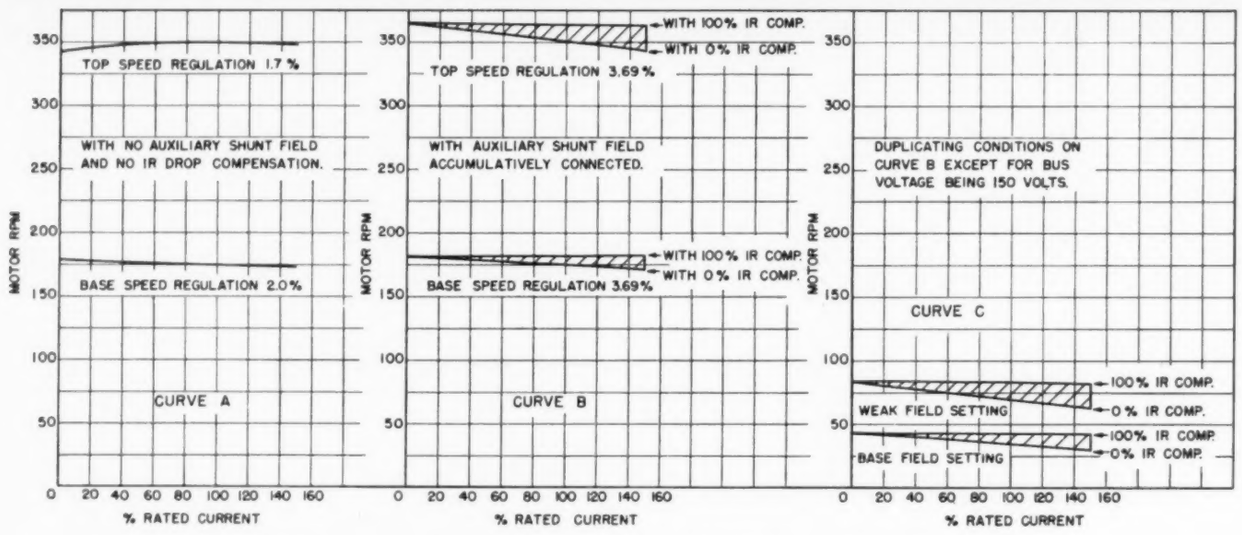

TOP SPEED REGULATION 1.7 %
WITH NO AUXILIARY SHUNT FIELD AND NO IR DROP COMPENSATION.
BASE SPEED REGULATION 2.0%
CURVE A
TOP SPEED REGULATION 3.69 %
WITH 100% IR COMP.
WITH 0% IR COMP.
WITH AUXILIARY SHUNT FIELD ACCUMULATIVELY CONNECTED.
BASE SPEED REGULATION 3.69%
CURVE B
DUPLICATING CONDITIONS ON CURVE B EXCEPT FOR BUS VOLTAGE BEING 150 VOLTS.
CURVE C
WEAK FIELD SETTING
BASE FIELD SETTING
MOTOR RPM
% RATED CURRENT

Figure 8 — Speed regulation curves for a 2500 hp, 175-350 rpm motor at 750 volts.

per cent speed regulation at 0 per cent compensation.

No attempt is made to obtain flat speed regulations closer than ½ of 1 per cent, as changes in motor heating, brush seating, or brush position will alter any otherwise accurate speed regulation adjustment. If the motor armature circuit resistance increases 10 per cent due to heating, a 100 per cent compensated motor (at room temperature) will have a drooping speed of 0.4 per cent with hot copper armature circuit windings.

METHOD OF CONDUCTING TESTS ON GAUGE CONTROL

Recently, oscillographic tests were made on a 5-stand tandem mill while rolling tin plate. The tests were made over a two day period, when rolling the one large order of tin plate. Other conditions, such as coolant temperature and coolant composition, were held as nearly constant as possible. Since gauge control was the object of

TABLE I — Test Data on Tandem Mill Motors (Showing method of adjusting per cent speed regulation with per cent IR drop compensation.)

Column 1	2	3	4		5	6†	7	8
Stand number	Hp	Motor speed range (rpm)	Speed regulation at rated voltage		Per cent IR drop** for 100 per cent compensation of motor circuit only	Maximum "safe" per cent IR drop compensation	Total IR drop compensation in motor and booster circuit, per cent	Booster volts (100 per cent load)
			Base speed	Top speed				
1	800	300/750	3.8	5.1	3.7	3.7	4.3	32.3
2	2000	100/250	4.2	5.0	4.4	4.2	4.8	36.0
3	2000	175/350	3.3	4.9	3.7	3.3	3.9	29.3
4	2500*	275/550	3.6	4.2	3.9	3.6	4.2	31.5
5	3000*	400/700	3.2	5.2	3.2	3.2	3.8	28.5

†Above these values the motors will have rising speed characteristics.
*Double armature motors with armatures in parallel.
**Includes only motor armature, commutating fields, compensating fields and brush drop.

the test, an attempt was made to have the operators make no mill screw-down or mill speed adjustments during the acceleration periods. The two broad conditions for the test were those with various values of tapered tension by field control and/or various settings of per cent IR drop compensation. The mill was completely equipped with both these means of gauge control.

Oscillograms were made of finishing gauge, mill speeds, tensions between stands, and input to the delivery tension reel. Of prime importance was finishing gauge, fifth stand delivery speed, and tensions between all stands. The output from the flying micrometer was amplified in a vacuum tube amplifier, the output of which was put through an oscillograph element. The stand speeds were measured by tachometer voltage readings on the oscillograph. Lastly, tensions were measured by the electrical output from tensiometers located between all stands. Schematic oscillograph connections are diagrammed in Figure 9.

Representative results of the tests are herein shown. Because the width of the oscillogram films were limited, the various traces of gauge, speeds, and tensions were made to overlap. Therefore, the original oscillograms were replotted exactly to scale but with the horizontal traces separated.

Table II gives a typical rolling schedule for all tests. Per cent reductions on all stands were maintained relatively constant throughout the tests.

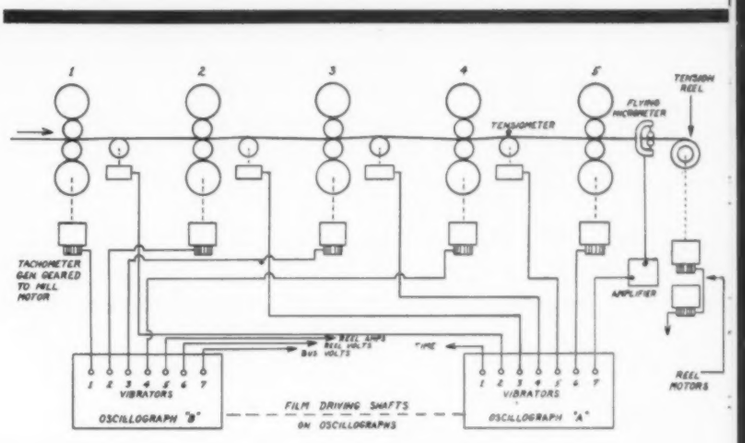


Figure 9 — Schematic arrangement of oscillograph for gauge tests on tandem cold mill.

RESULTS OF TESTS ON TAPERED TENSION

The oscillogram tracing in Figure 10 shows some conditions of mill operation during the accelerating and decelerating periods. The top dotted lines give the one-half second time impulse indications. The second curve gives the delivery speed from the fifth stand. The finishing gauge is that obtained from the output of a flying micrometer, located between the fifth stand and the delivery reel. Tensions between the mill stands are shown on the lower four curves. "Pounds Tension 1-2," for example, is that strip tension occurring between stands 1 and 2. Figure 10 does not include the complete interval required for rolling the coils. Coils averaging over 9000 pounds, each, were rolled, so that the finished strip length per coil was about 9300 feet. This means that the "time interval" shown on Figure 10 represents a lapse of 3 minutes approximately, when rolling at 3000 fpm.

There are two important conditions that should be borne in mind. The operators, first of all, were thoroughly familiar with the mill, and had the mill conditions (running tensions, drafts, screw positions, etc.) at the best operating point possible. As is always the case, a competent rolling crew is an extremely factor in mill operation. Secondly, during acceleration and deceleration periods, the operators did not touch any screw-downs or mill motor speed rheostats. Only after the mill had levelled off at running speed were the mill motor speed rheostats changed in position.

In Figure 10 the mill was accelerated by voltage control from a threading speed of 280 fpm to a finishing speed of 1940 fpm. After operating at this speed for three minutes, the mill was decelerated to a threading

TABLE II — Typical Tandem Mill Rolling Data
(Mill at operating speed for oscillographic tests)

Stand	1	2	3	4	5	Tension reel
Delivery, fpm	486	853	1,650	2,270	3,290	....
Per cent reduction	22	43	48	27	31	....
Tension, pounds	60,000	34,000	23,000	18,000	4,600	....

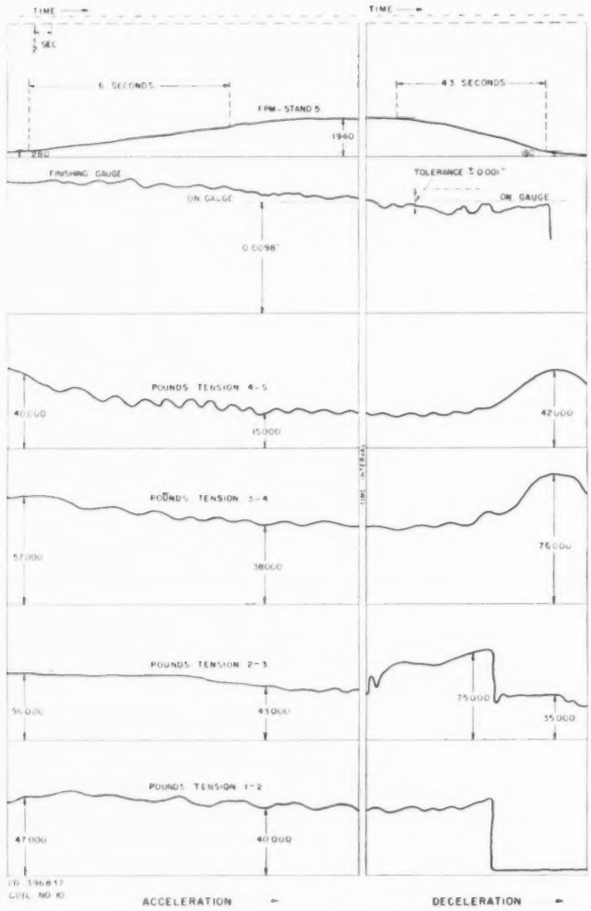
Material rolled: Grade No. 1 steel — coil No. 33; coil weight: 9,670 pounds; starting width and thickness: 28 7/8 in. by 0.085 in.; finishing thickness: 0.0098 in.

Power input to main M-G set: 9,300 kw

speed of 180 fpm. Gauge was obtained at 1900 fpm on acceleration and held down to threading speed. (Similar readings were subsequently made when accelerating to 3000 fpm. Gauge was obtained near 3000 fpm and held on down to about threading speed.) Note that the operating conditions were those of a conventional variable voltage mill without any boosters and without any manual or automatic means of increasing the tensions at low speed. Figure 10 does show some increase in tension between stands at lower speeds, however. This

The tension oscillograms also fluctuate somewhat. Slight variations in strip hardness and thickness, as well as roll roundness probably accounts for most of this effect. The sudden drop off in tension 1-2 is due to the rear end of the strip leaving stand No. 1. The strip tension between stands No. 1 and 2 in Figure 10 was relatively constant.

If we now apply tapered tension on acceleration and deceleration, we get the oscillogram tracing of Figure 11. Here the field of stand No. 1 motor was automatically



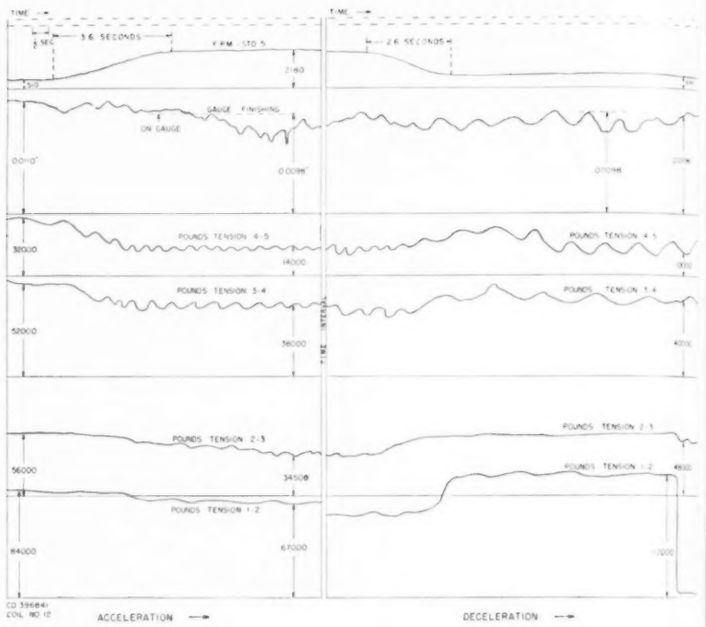


Figure 10 — (left) Oscillogram record with no tapered tension on IR drop compensation.

Figure 11 — (above) Oscillogram record with no IR compensation but with 5.5 per cent tapered tension on stands 1 — 2.

is the result of the gauge tending to get thicker at lower speeds and the resulting inherent tendency for the mill to increase strip tension. The mill motors do inherently maintain speed correspondence to some degree.

Before proceeding further, a few more explanations concerning Figure 10 are in order. The gauge variation is pronounced because of no electrical damping in the vacuum tube amplifier outfit which gave an indication of gauge. Normally the gauge indicating instruments are damped sufficiently so that they do not accurately follow quick thickness changes. The oscillogram of gauge at threading speed shows little variation in gauge. This would be expected, for the micrometer more closely follows the strip and the thickness changes occur more slowly at low strip speeds.

weakened as the mill was accelerated; so that the tension between stands No. 1 and 2 was greatest at low speeds. By tapered tension control we can get gauge at 1000 fpm, and hold it down to 700 fpm. Once again, it should be remembered that no manual attempt was made to get gauge sooner. Obviously, by manually increasing the tension between, say, stands No. 4 and 5, gauge could be obtained a little sooner.

The upper portion of Figure 14 gives a summarized test result with and without tapered tension. When operating at 3000 fpm, the shaded area shows that without any tapering of tension, the strip is on-gauge at 80 to 100 per cent speed, without any manual or automatic aid. By tapering the tension between stands No. 1 and 2 by 5.5 per cent, on-gauge may be obtained

at 30 to 60 per cent speed. By "5.5 per cent taper" is meant the per cent speed increase of stand No. 1 if its motor voltage were held constant and its field were weakened over the tapered tension range under consideration.

RESULTS OF TESTS ON IR DROP COMPENSATION

Now, removing all forms of manual or automatic methods of tapering tensions by motor field control, let us consider only IR drop compensation. Figure 12 shows gauge conditions with 95 per cent IR drop compensation on the stand motors. Normally all IR boosters will be set to carry the same per cent compensation on all stands. Now we find that gauge comes "on" at threading speed, shortly after the delivery reel has been threaded. Gauge is also maintained all the way up to the running speed of 2960 fpm, and down again (on deceleration) to threading speed.

Of particular interest are the increases in tension between stands. All tensions are automatically increased at lower speeds so that the strip thickness remains correct. The strip tensions all increase up to the point where gauge is obtained, and no further. Strip breakages are therefore less likely than with other means of "gauge getting."

A summary of all test data on IR compensation was plotted, the results of which are illustrated in the lower portion of Figure 14. For various degrees of IR compensation, the shaded area shows the range in speeds at which gauge "comes on" during acceleration. The closer the per cent IR drop compensation approaches 100 per cent, the more easily on-gauge is obtained at threading speeds. Compensations too close to 100 per cent compensation can result in speed instability, however.

TESTS WITH BOTH TAPERED TENSION AND IR COMPENSATION

Since either method of gauge control is potent in reducing off-gauge during acceleration and deceleration, why not combine the two methods? Figure 13 shows gauge conditions with 95 per cent IR compensation and 2.5 per cent tapered tension at stands No. 1 and 2. The performance of the mill is little different than with 95 per cent compensation and no tapered tension. However, if only 50 per cent compensation is used, then tapering tension will give almost the same results as 100 per cent compensation.

COMPARISON OF TAPERED TENSION AND IR COMPENSATION

Tapered tension by motor field control has the following advantages:

(a) It can reduce "transient off-gauge" tonnage. That is, the scrap loss during acceleration and deceleration can be reduced by tapered tension.

(b) It can be added to the mill control at practically no cost.

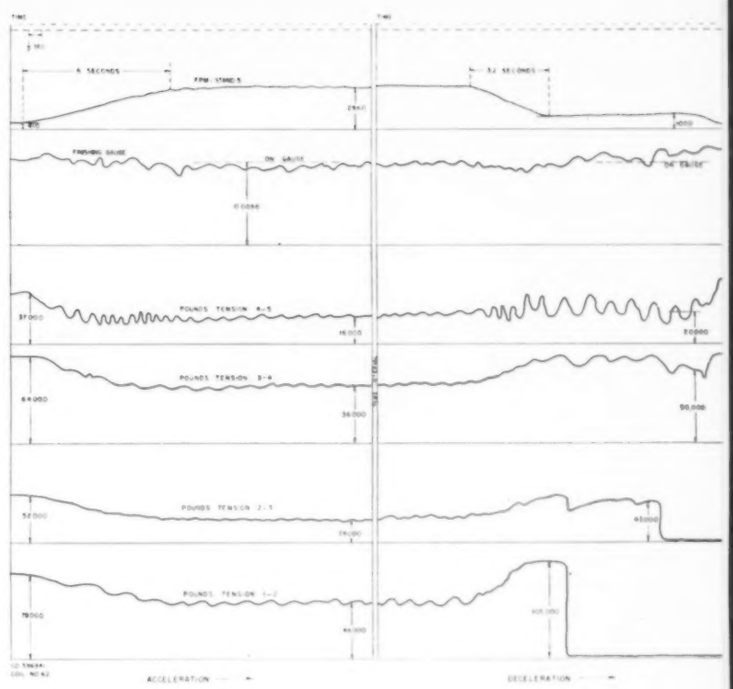
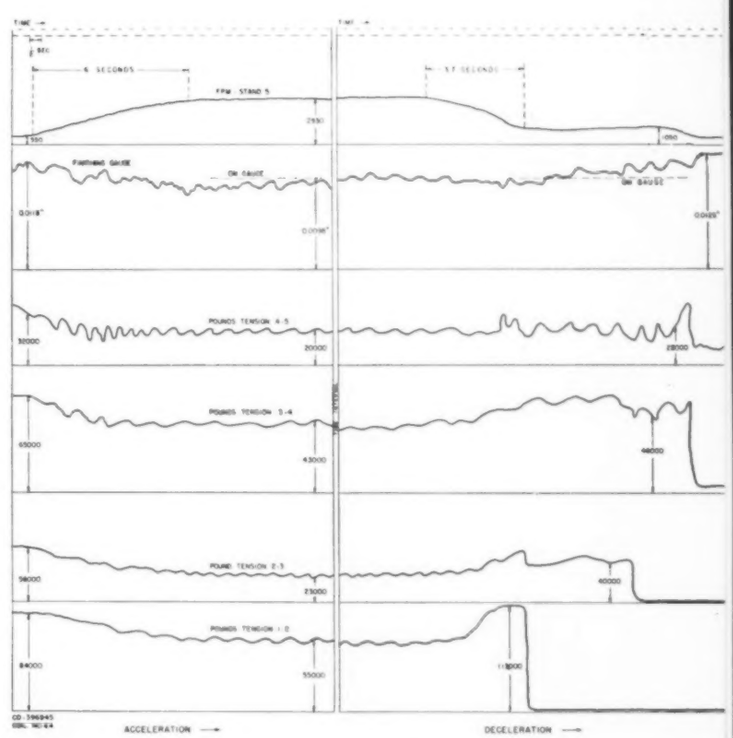


Figure 12 — Oscillogram record with no tapered tension, but with 95 per cent IR compensation on all stands.

Figure 13 — Oscillogram record with 2.5 per cent tapered tension on stands 1 — 2, and with 95 per cent IR compensation on all stands.



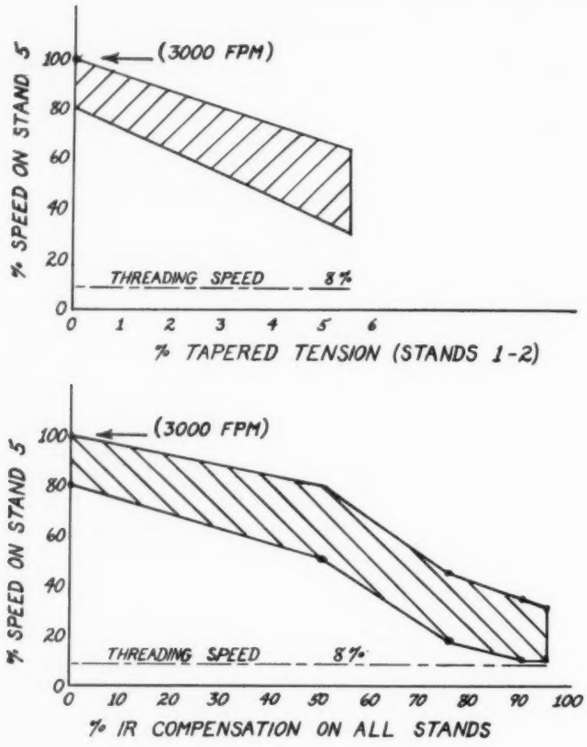


Figure 14 — Comparison of tapered tension and IR drop test data on gauge control. Shaded areas give range in which gauge is obtained on acceleration.

These conditions will generally hold true, regardless of the speed of type of tandem mill.

On a high speed tandem mill the following is evident when using IR compensating booster generators, operating at high percentages of compensation (say, 95 per cent):

(a) IR drop compensation can be, like tapered tension, a definite means of reducing off-gauge.
(b) More rapid and uniform acceleration rates on the mill are possible.
(c) After reaching running speed, gauge conditions are more steady because of the "stiffness" of speed correspondence.
(d) Because tensions between stands are held at a high value during deceleration, the rear end of the strip can go through the mill at a high speed, without jumping out of the guides. Thus the operators can "clear the mill" at higher speeds.
(e) Because tension conditions can be controlled within limits, strip breakages due to excessive tensions can be eliminated.
(f) In selecting the mail mill motors, little attention need be paid to balancing of armature WR^2 values, for uniform acceleration.

THE ECONOMICS OF TAPERED TENSION AND IR BOOSTER CONTROLS

Any addition to a tandem mill quite properly raises the question, "Will the addition pay for itself?" Adding tapered tension control is inexpensive, and it can most certainly be made to "pay." Adding IR boosters to a mill means a money outlay of 5 or 10 per cent of the total mill electrical equipment cost. In some installations this outlay is warranted. In other installations IR boosters will do a job that is very little better than that done by tapered tension control.

What type of installations warrant the addition of IR booster generators? Operating experience has been gained on a five stand tandem mill equipped with boosters. Similar operating experience has been on 5-stand, 4-stand and 3-stand tandem mills, all equipped with tapered tension control. It appears that IR boosters can advantageously be applied to mills that meet all the following conditions:

(a) The mills roll large orders of one kind, such as tin plate mills, or those rolling automobile body stock.
(b) Rolling is at speeds where the running speed is considerably above the threading speed. In this category fall such mills that thread at a few hundred feet a minute and run above one thousand feet a minute.
(c) The mills have four or five stands in tandem.

There are many cold mills in this country that have only two or three stands in tandem. They operate at relatively low speeds (300 to 800 fpm). They may also roll a wide range of products, the products differing in gauge, width and properties. It is in these types of mills where tapered tension usually shows reductions in off-gauge material, but where the addition of booster generators to each stand motor will show little gain over tapered tension.

Gauge control during the accelerating and decelerating periods may thus be summarized as follows. Tapered tension control can easily be applied to advantage on all types of tandem mills. Booster generators for each mill motor have a narrower field of application in that they result in greater off-gauge savings in large, high speed tandem mills which have more than three stands.

DISCUSSION

PRESENTED BY

T. B. MONTGOMERY, Engineer in Charge, General Control Division, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

G. E. STOLTZ, Electrical Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

J. D. CAMPBELL, Industrial Engineering Division, General Electric Company, Schenectady, New York

T. B. MONTGOMERY: I have just a few general comments to make, quite general of course. It is particularly interesting, I think, to note in this paper, which we certainly think is quite a contribution to the extensive data that has been gotten together on gauge control — and we feel that it is sufficiently important that our very best efforts should be given to it — *the degree of speed regulation used.*

But as I started to say, this question of speed regulation seems very interesting from the data that was presented, because we know that we can get into difficulty by IR drop compensation for speed regulation, if regulation is made too close.

It is very interesting to see just how far practically you can go with that. In general, if we look at the problem where we have the IR drop to overcome, which varies with speed, so far as electrical equipment is concerned, and also the mechanical phenomena where the gauge changes with the speed of the mill, it seems that the problem becomes one of several mechanical loads operating in parallel, subject to separately varying conditions — both mechanical and electrical.

From our experience we have found, too, that on a tandem mill, the various mechanical factors are tied together more stably than they are on a single stand mill, but nevertheless the same problem obtains on a single stand mill. In that connection on the single stand mill, in one case the design was laid out to accelerate the mill to 1640 fpm in five seconds, which was found to be quite impractical. As it worked out, an accelerating time, somewhere in the neighborhood of 16 seconds worked best, whereby the operator gets gauge and holds it while the mill is accelerated.

One other factor which Mr. Campbell mentioned is that the amplidyne generator is a tool which has aided very much in this tapered tension control. Also, we have found that, with regular exciters, for instance, doing a similar job we can accelerate in at least two-thirds the time that could be done with the old control.

Just one additional point; since it is a mechanical job, that is to say we must keep the ratio of a mechanical torque, and tension on speed proportional under several varying factors, some electrical and some mechanical, a mechanical device, the tensiometer, is certainly required in the scheme, and in that connection we have found it is most important that in its operation the tensiometer should disturb the pass line of the strip as little as possible.

G. E. STOLTZ: It seems to me this question of holding gauge is a fairly simple one. It is a fundamental that the product of speed and thickness of strip out of the stands should be the same, aside from the very small variation in creep of metal slightly faster than that of the roll speed. But there is not enough difference between what happens on each individual stand to make this an important factor.

I would suggest an approach to this problem a little more simple than Mr. Campbell has attacked it, that is, set and maintain the speed relationship of the individual motors to obtain the gauge desired. That has been done on tandem mills of this type for several years. If this develops dangerous tension between stands then some relief will have to be given at the possible expense of off gauge.

If we could assume that the coil from the hot mill comes to the cold mill of uniform thickness, and if we have properly compensated motors, fixed gauge will be obtained regardless of variation in mill speed and without any regulating scheme. If the coil does not come to the mill of uniform thickness throughout its length, then the place to change this is between one and two stands, where the strip is heavy, is not likely to break, where the delivery speed is slow, and where you have a good opportunity to make such a correction.

I think this question of obtaining what we want is fairly simple, and does not require a great deal of special apparatus. Mr. Campbell has mentioned the use of an amplidyne. I don't know why we can't use a series exciter, that will give the necessary response without the additional apparatus.

J. D. CAMPBELL: The comments made by Mr. Montgomery and Mr. Stoltz were very pertinent, in so far as gauge control is concerned, and I wish to thank them for their clarifying points.

We have found several benefits in using the amplidyne control of IR boosters, rather than using straight series wound booster generators. Booster generators with series fields are difficult to adjust for various percentages of IR drop compensation. Furthermore, residual voltages in series generators cannot be kept to a desirably low value. If the booster generator is built with a low resistance shunt field, the field can be connected across the mill motor commutating and compensating field winding. The disadvantage in this latter scheme is that the shunt field is relatively inductive so that the booster voltage lags the mill motor armature current.

With amplidyne control of the shunt field in the IR booster generator, we can regulate the booster voltage from zero compensation to 100 per cent compensation. Residual voltage on the booster can, therefore, be controlled. By means of a small rheostat in the amplidyne field, the per cent compensation setting can be easily changed, when the mill first goes into service. The inherent "forcing" in the amplidyne regulator enables the booster voltage to respond quickly to motor armature current changes.

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THE APPLICATION OF *Mercury Arc Reflectors* IN STEEL MILLS

. . . . a direct comparison of the relative merits of mercury arc rectifiers and synchronous motor-generator sets as conversion units for d-c power shows the advantage to be on the side of the rectifier . . . .

by A. D. Howry, ELECTRICAL ENGINEER

ALAN WOOD STEEL COMPANY

CONSHOHOCKEN, PENNSYLVANIA

▲ THIS subject, treating on a type of equipment that was not introduced into steel mill practice until 1937, when the Republic Steel Corporation installed a 1000 kw 250 volt rectifier in their wire mill at South Chicago, has since that time received a considerable amount of discussion, most of which has been presented by the manufacturers' engineers.

In the first place, let us clearly understand that the mercury arc rectifier, as a piece of equipment, is not a new development. It has been used in Europe for approximately 50 years, primarily in railway work, and later in the steel industry; America was not slow in adapting this new invention, (which incidently was invented by Peter Cooper Hewitt, an American), and have added a considerable number of improvements, including grid control, which provides variable d-c output, and the single anode tank, which reduces arc drop loss and therefore makes it economical to use on 250 volt d-c systems, which is the constant potential used in most steel mills.

We in the steel industry are always laying greater stress, and rightly so, on operating reliability than on efficiency of electrical equipment. When our mills are operating at full capacity, as at present, even an hour shut-down once a month may be more costly than the losses due to a few per cent lower efficiency in alternating to direct current conversion units. Also when we consider the change or addition of a conversion unit, we must realize that our operating and maintenance personnel knows how to operate and repair a motor-generator set, which is the type of conversion unit used almost exclusively by the industry, while a rectifier is something with which we are not familiar. This raises a psychological obstacle which can be overcome only by becoming more familiar with the operation and maintenance of the rectifier.

As the purpose of this paper is to show the practical and economical application of rectifiers, rather than a technical discussion of rectifier construction and operation itself, we shall first review the typical steel plant power system; a brief discussion on how the conversion is accomplished; efficiency comparison with the conventional motor-generator sets; operation problems and economies and an outline on the effect of the rectifier on the power system.

Basically the power system of the average steel mill consists of generation by the use of blast furnace gas, alternating current distribution at either 25 or 60 cycle to centralizaed substations where the conversion to direct current is accomplished by the use of synchronous motor-generator sets.

A large part of all power thus generated is converted to direct current for use by auxiliaries, cranes, lifting magnets, etc. This load is anything but stable; for instance, the peak demand for any one department may reach 1500 kw momentarily, wherein the average may be around 600 kw with dips to possibly 200 kw. In addition, most direct current lines are quite long due to the grouping of motor-generator sets at attended substations. This necessitates abnormally heavy distribution cables to reduce line drop losses; where this line drop loss is abnormal difficulty is experienced with overheating of motors, failure of magnetic control, etc. This

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condition naturally is accenturated by increased war production demands.

It is evident that as this condition becomes increasingly critical definite action must be taken to increase the direct current generation capacity. An analysis of a system may show that the load centers are remote from the power generation source, and that certain economics of distribution and maintenance must be considered before any additions are made. In this case, a decision must be made between the installation of the new conversion capacity at the central attended substation with correspondingly increased capacity of distribution cables, or the installation of automatic controlled units close to load centers with its decreased use of heavy distribution cables. Shall we install the tried and proven motor-generator set with which we are all familiar? Or shall we consider the installation of this new mercury arc rectifier of which we know so little?

Here in lies the problem of operating reliability, efficiency and maintenance. Before these subjects can be properly discussed a brief description of the construction and operation of the mercury arc rectifier should be made.

A rectifier is, in effect, an electric check valve. It functions in this manner because of its property of presenting a low resistance to the passage of current in one direction and a high resistance in the opposite direction.

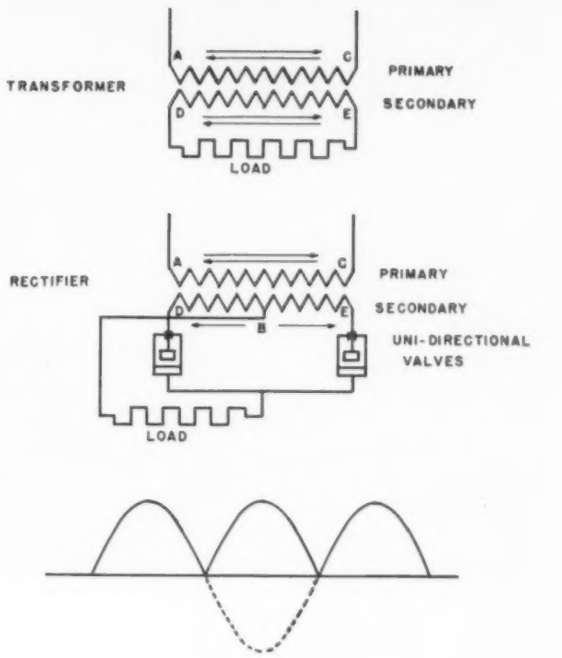
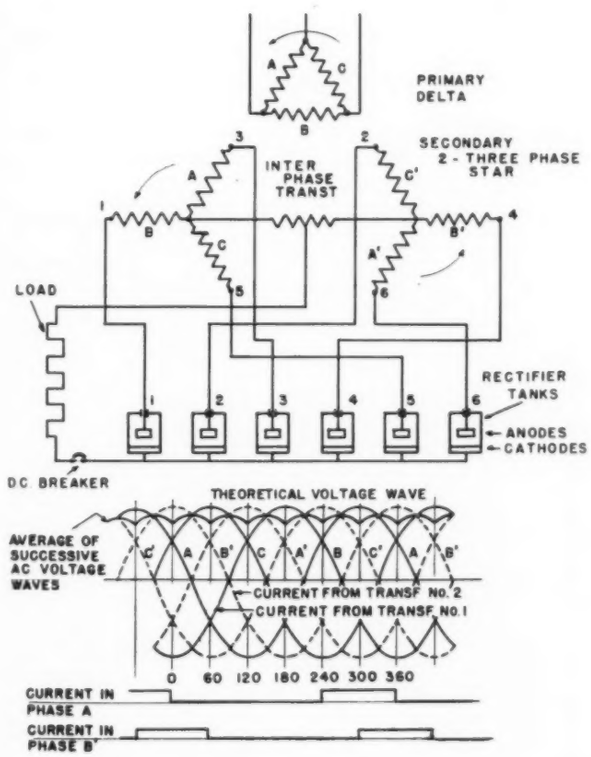


Figure 1 — Diagram of single phase mercury arc rectifier.

Figure 2 — Diagram of six phase ignitron or excitron type mercury arc rectifier.



The simplest practical form of full wave rectification consists of a single phase transformer with a valve element in each leg of the secondary. The return circuit is connected to the mid point of the transformer winding. This is illustrated in Figure 1, in comparison with a single phase transformer circuit; the current flow in the transformer circuit reverses direction with the frequency; wherein the rectifier circuit having a unidirectional valve in each leg of the transformer, limits the flow of current to one-half of the transformer secondary winding in any one-half cycle. As the current in the primary of the transformer flows left to right or A to C a voltage is set up in the secondary from right to left or E to D; as the unidirectional valve permits flow of current in one direction only, the current will flow only in the left half of the winding or from B to D, through the valve, the load, and back to neutral connection at B. The valve to the right will not permit current to return to the transformer connection E so that the windings from E to B are idle during this half cycle. When the current reversed in the primary of the transformer, that is from C to A, the transformer secondary flow is from B to E through the opposite valve, the load, and back to neutral at B again, only one valve or rectifier unit operating at any one time. With this single phase rectification the current through a resistance load is d-c in the form of half waves as is shown above the horizontal line in the wave diagram of Figure 1.

For large capacities, it is imperative that we have a direct current voltage of a more uniform value than could be obtained by single phase rectification.

To obtain this result a six or more phase rectifier is normally used. A six phase rectifier with interphase transformer is shown in Figure 2. Here the primary

Figure 3 — Conventional metal tank unit mercury arc rectifier, 2750 kw, 600 volt d-c.

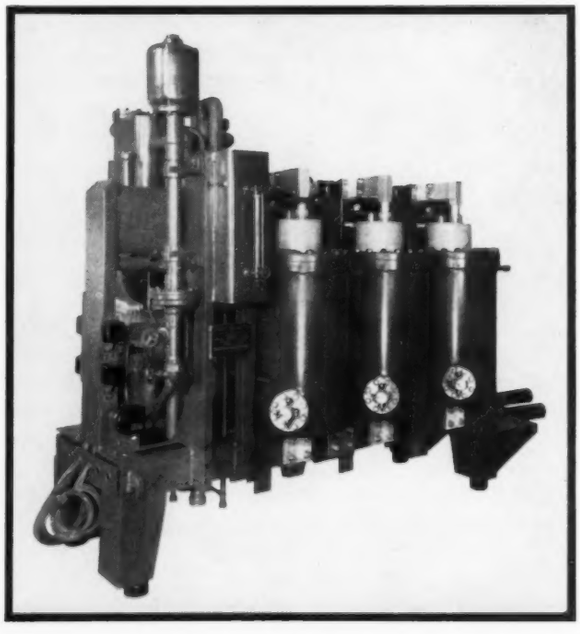
phases are joined at their terminals to form a delta to receive power from a three phase source. Each of the primary phases have two corresponding magnetically coupled secondaries, in which are induced voltages in the same phase position as in the primary winding.

We have shown in Figure 1 that the secondary current flow for any one-half cycle is from the mid point to terminal with the other half winding idle. In order to reduce the heating effect on rectifier transformer and lower the peak anode current two three-phase star connected secondaries are generally used with their neutrals connected through an inter-phase transformer; this in effect gives us six phase operation. By alternately stepping from one secondary to the other, we produce six rotating voltages, 60 degrees apart, in which each phase carries current approximately one-third of the time so that current is being obtained from two anodes at any given instant. The graphical representation of this voltage is shown on the curve of Figure 2. Here the left hand secondary waves are indicated by solid lines and the right hand secondary by broken lines. This rotation, which is comparable to the physical speed of a synchronous motor-generator set, is readily evident on this diagram and curve, as the primary phases are 120 degrees apart, and the split phase secondary windings carry current only during the positive half cycle in A phase. A corresponding current is produced in the secondary half of A phase winding, firing through the rectifier from the anode to cathode, through the load and back to neutral through the inter-phase transformer; 30 degrees before A phase reaches its peak B phase starts to build up on its negative half cycle producing a corresponding current in the secondary half of B′ phase, firing order being A, B′, C, A′, B, C′, etc. The envelope of the average of the successive a-c secondary voltage waves is the output d-c voltage, the interphase transformer acting as a step up auto-transformer when the terminal voltage of one phase is below this average and as a reactance when the terminal voltage of the active phase in the other secondary is above this value.

This basically comprises the operation of the mercury arc rectifier. In construction the rectifier falls into two classifications; the conventional metal tank unit as shown in Figure 3, consisting essentially of a steel sheet vacuum tight welded tank, with an insulated pan at the bottom for the mercury pool cathode and six or more graphite anodes connected through vacuum tight insulated bushings to anode terminals at top of the tank; and the recently developed multi-tank rectifier (shown in Figure 4) each tank containing its individual mercury pool cathode and a single graphite anode, one of these tanks being placed in each phase, with all cathodes connected together forming the positive terminal of the rectifier. This type of mercury arc rectifier is known as the ignitron or the excitron rectifier; basically both types are similar in appearance and operation, the difference being in the ignition circuits. The complete mercury arc rectifier consists of the main power rectifier transformer; the rectifier tanks; the a-c and d-c switchgear; the vacuum manifold connecting all individual tanks with a vacuum pumping system, consisting of diffusion type high vacuum mercury condensing pump, interstage receiver and a motor driven roughing pump, vacuum gauges, vacuum valves, etc.; a cooling system consisting of manifolds and connections to all tanks, a recirculating pump, heat exchanger, etc.; an excitation and ignition system; and a grid or voltage control system. This assembly is shown diagrammatically in Figure 5.

The basic principal of operation of both the single

Figure 4 — Multi-tank unit ignitron or excitron type mercury arc rectifier. 1000 kw, 250 volt d-c.



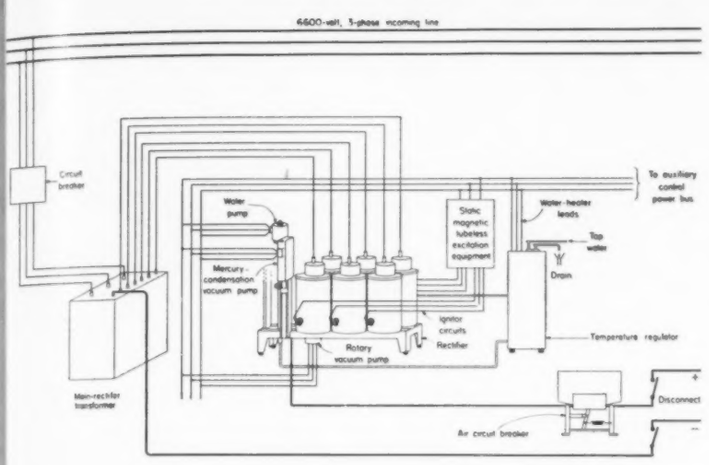


Figure 5 — Diagramatic arrangement of mercury arc rectifier installation.

tank multi-anode, and the multi-tank single anode rectifiers is the same, since rectification of alternating current into direct current power is accomplished by the uni-directional flow of the arc current. The main difference between the two types is that each anode in the multi-tank rectifier is not exposed to the highly ionized mercury vapor of the main arc current during its non-firing inverse voltage period as in a multi-anode tank and therefore the anode can be located closer to the mercury pool cathode of its individual tank. This results in a much lower arc drop loss and a resultant improvement in the efficiency of operation, as this arc drop loss is constant regardless of output voltage. It can readily be seen that this is a rather important factor in 250 volt operation.

The efficiency of the rectifier is the ratio of the power output at the direct current terminals to the power input at the high tension terminals of the transformer. Component losses of the unit included in the efficiency calculations cover the iron and copper losses of the transformer, the loss in the rectifier arc, and the power for operation of the rectifier auxiliaries. These losses compared to the standard motor-generator set are best shown in Figure 6, wherein we show the relative efficiency curves of the various types of conversion units of 750 kw capacity, both 250 volt and 600 volt. Here, we note that the rectifier curve is practically flat from 25 per cent load up to 125 per cent load; the efficiency at 25 per cent load being 91.2 per cent and at 100 per cent load 91.8 per cent; or a differential of .6 per cent. The motor-generator set as we note has a very decided drooping efficiency as the load drops, being 79.2 per cent at 25 per cent load, and 88.7 per cent at 100 per cent load, or a differential of 9.5 per cent. It is readily apparent that in fluctuating loads such as are common in steel plant operation this difference in efficiency can effect a considerable savings in a period of time. These efficiencies are given us by the manufacturers; in actual practice, the records show that in 12,500 hours of operation of the previously mentioned 1000 kw, 250 volt rectifier installed by the Republic Steel Corporation, the input was 2,216,500 kwhr, out-put 1,950,000 kwhr, load factor 15.6 per cent, efficiency 88 per cent. A 1000 kw motor-generator set operating under identical load conditions would have an efficiency of 73 per cent. Efficiency savings amount to $3,369.00. The maintenance costs during this period amounted to:

72 hours labor at $1.10	$ 79.20
Cooling water cost	154.00
Oil for vacuum pump	3.80
Total	$237.00

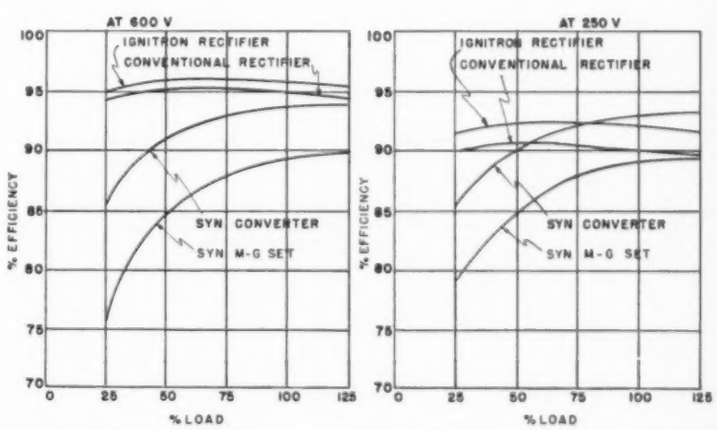
This shows a net savings of $3,132.00 for a period of 521 days of operation or approximately $6.00 per day.

One outage occurred during this time, a ten minute interruption due to accidental pressure drop in the mill water supply which tripped the water pressure relay.

From this we can see that the rectifier has a high overall conversion efficiency practically constant over the entire load range; it has a high momentary overload capacity as the rectifier units are basically a current device, the magnitude of the overload being limited only by the thermal capacity of the equipment.

The operation of the rectifier is a relatively simple procedure comparable to energizing a transformer bank; as there are no major rotating parts such as are present in a motor-generator set, we do not have any starting sequence, synchronizing, field control for paralleling with other units, etc.; this is all inherently built into the rectifier control and is an automatic operation. The response is instantaneous; upon closing of the main a-c breaker, the transformer and rectifier are energized, the d-c breaker closes and the rectifier is on the line carrying the full load imposed upon it. This factor alone differing from a motor-generator set where the load must be built up gradually as the field is strengthened, may prove of incalculable value when every minute counts. This instantaneous response to load conditions is due to the fact that the rectifier units are basically a current device, voltage being governed by the transformer ratio; as the only moving parts attached to the rectifier are the water recirculating pump, which is con-

Figure 6 — Relative efficiency curves of various conversion units of 750 kw capacity.



RECTIFIER UNIT	MOTOR-GENERATOR

POWER FACTOR

92 to 93 per cent between ¼ and 1¼ load, about 88 per cent on 10 per cent load. About the same for either frequency.

May be corrective leading.

EFFICIENCY

Load	¼	½	¾	1	¼	½	¾	1
Overall efficiency, per cent	91.0	92.0	91.5	91.5	78.0	85.5	88.0	89.0

The above rectifier and motor-generator set efficiencies hold approximately good for either supply frequency.

POWER SAVING ABILITY

Owing to the higher overall efficiency the annual power saving as compared with a motor-generator set, based on a 24-hour day, 365-day year and a power rate of 1c per kwhr is approximately $1,250 at 10 per cent load factor, $4,000.00 at 40 per cent, $3,500.00 at 80 per cent and $3,250.00 at 100 per cent load factor.

OVERLOAD

Will withstand heavy momentary overloads without damage.

Will withstand small or medium overloads for longer time due to larger heat absorbing capacity.

COOLING

Basic cooling is closed water recirculating system. With water to water or water to air exchange.

Basic cooling is air which must be of large capacity and filtered to prevent dust and grit from being blown into windings.

MAINTENANCE

Records kept of a large number of installations seem to indicate that rectifier units require only approximately half the maintenance of equivalent rotating machinery.

For a number of 600-volt rectifier units supply traction loads and ranging from 500 to 3000 kw in capacity, average maintenance expenses of $363.00 per year were observed.

For a 1000-kw, 250-volt rectifier unit in a steel mill, a total maintenance cost of $237.00 per year has been reported.

For a number of rotating type converting sets, having unit capacities from 1500 to 3000-kw at 600 volts, annual maintenance costs of $703.00 per set are on record.

OBSOLESCENCE

Rectifier equipment improves with age as the evacuation of all foreign gases becomes more and more thorough. Only minor auxiliary apparatus is subject to wear.

The value of rotating equipment decreases with time.

VOLTAGE REGULATION

Owing to transformer and line reactance, copper losses and arc drops, rectifier units have inherently a drooping or shunt type voltage characteristic.

By means of grid control, flat or over-compounded voltage characteristics can be obtained.

A-c voltage variations which are transmitted to d-c side, can be automatically compensated by grid control.

Voltage rise at very light load may be held down by simple and inexpensive control devices.

Subject to control by field rheostat. Flat or over-compounded voltage characteristics can be provided with compound windings. Moderate a-c voltage variations do not affect d-c voltage.

PARALLEL OPERATION

Operation in parallel with other rectifier units, or rotating machinery in same substation satisfactory when voltage characteristics are similar.

Grid voltage control permits division of load as desired.

Similar voltage characteristics required to insure satisfactory parallel operation with other converting equipment.

NO-LOAD LOSSES

No-load losses of rectifier units are from ¼ to 1/5 those of rotating type machinery. Rectifiers therefore particularly suitable for applications where long no-load or light load periods prevail.

Rectifiers can be left floating on supply lines during such times without appreciably affecting substation efficiency.

The friction and windage losses of rotating machinery increase their light and no-load losses, necessitating an unattended substation expensive and complicated load responsive control where long light-load periods prevail.

WEIGHTS

Rectifier tanks, auxiliaries, coolers, 25 or 60 cycle, usually installed indoors ..... 13,000 lb
OISC transformer, 60-cycle, usually outdoor type ..... 24,000 lb
Total ..... 37,000 lb

Rectifier tanks, auxiliaries, coolers, 25 or 60 cycle, usually installed indoors ..... 13,000 lb
OISC transformer, 25 cycle, usually outdoor type ..... 36,000 lb
Total ..... 49,000 lb

Does not include any switchgear.

Motor-generator set for 60-cycle supply installed indoors ..... 54,000 lb

Motor-generator set for 25 cycle supply, installed indoors ..... 67,000 lb

Does not include any switchgear.

FOUNDATIONS

Foundations are not subject to vibrations and therefore can be designed to carry dead weight only.

Foundations must be constructed to withstand vibrations and weight of equipment and permit access of cooling air through base and foundation.

PROTECTION AGAINST DUST AND DIRT

Active parts are all completely enclosed and therefore not subject to dust and dirt in air. Water cooling of rectifier prevents dust and dirt in atmosphere being carried into substation. External insulation consists mainly of smooth porcelain, mycalex, etc.

Transformer windings are oil insulated.

Windings and cores exposed to air, dust and dirt, difficult to clean, and are thus subject to rapid aging and deterioration.

SAFETY FROM CONTACT

Rectifier tanks and auxiliaries are alive when in operation and must be protected against accidental contact by rail or screen.

Frame and shields can be grounded thus reducing hazard of contacting live parts.

STARTING AND STOPPING

Starts instantaneously on full voltage without any shock to system. No starters required. No danger of reversal of polarity. Drooping shunt characteristic prevents excessive current drain and assists proper division of load. No back-feed possible.

Easy adaptability for automatic starting and stopping.

Starting produces shock to a-c system unless reduced voltage starting provided. Starting-up and synchronizing, time-consuming.

Voltage must be adjusted for paralleling. Backfeed and motoring of set if voltage not adjusted right.

Push-button starting requires considerable extra control equipment.

STABILITY

Rectifier will remain in operation during severe a-c line disturbances. No falling out of step during severe overloads.

Disturbances on a-c lines or severe overloads are liable to pull synchronous machinery out of step or cause the tripping of breakers. Motor cannot be started up again until normal system conditions are restored and maintained.

FREQUENCY

Rectifier equipment can be used on two or more frequencies, providing transformer is built accordingly. This feature is of importance where a subsequent change of frequency is anticipated or where unit is to operate at times from systems having different frequencies.

Frequency is fixed by design and speed of set.

VOLTAGE

Rectifier equipment is suitable for various d-c voltages and subject to the secondary voltage of the transformer equipment. A-c voltage changes are transmitted to d-c side unless automatic grid voltage control is provided.

Voltage is fixed by design and speed and subject to variations of supply frequency. A-c voltage variations are not transmitted to d-c side.

REGENERATIVE BRAKING

Normally not suited to regenerative braking. Standard regenerative braking control is available, it is simple and inexpensive. When a large number of motors are on the circuit these motors will absorb the back feed.

Satisfactory for regenerative braking.

WEAR

Principal operating parts are not subject to wear. Anodes and cathodes neither receive nor give off material. Moving parts consist of small auxiliary devices only. Lubricating and similar attentions not usually required.

Bearings require periodical lubrication and careful attention. Both bearings and commutators need continuous attention. Windings are subject to deterioration due to dust, heat, moisture, etc.

NOISE

Operation practically noiseless.

Noisy operation but generally not objectionable in industrial plants.

INSPECTION

Parts subjected to wear and requiring inspection accessible.

Parts subjected to wear accessible for inspection. Armature windings difficult to clean.

INSTALLATION

Relatively simple and inexpensive requiring little floor space, headroom and foundation. No special lifting gear required.

Careful aligning on foundations required. Owing to great weight of heaviest parts, suitable lifting gear necessary.

trolled by a thermal relay, and the vacuum pumps, which are governed by a vacuum relay, no additional operating procedure is required. These pumps, which can be compared to a standard refrigerator unit, need only an occasional inspection and change of oil.

The rectifier, having no moving parts except these small pumps is extremely quiet in operation; being completely sealed, it is little affected by dust, moisture and corrosive fumes.

Maintenance consists basically of inspection and cleaning with occasional renewal of oil in the auxiliary pump. There are no brushes, commutators or bearings which require periodic maintenance and replacements; the rectifier is immune to damage from frequent short circuits, a contributing factor to the maintenance of the motor-generator set; there are no windings subject to deterioration and replacement.

The relays and control used in rectifier operation are somewhat different than those with which the average steel mill maintenance man is familiar, but here again is a matter of proper instruction.

Unquestionably the greater efficiency of the mercury arc rectifier over that of the synchronous motor-generator is such that we must give it serious consideration when we contemplate changes or additions in our direct current generating capacity. Before a definite conclusion is reached we must consider what effect the rectifier will have on our alternating current system. We have been depending on the synchronous motor-generator sets to provide power factor correction for our system, particularly as we may have some large mill units driven by wound rotor induction motors. What contribution, if any does the rectifier make to this system?

The 80 per cent power factor synchronous motor-generator set delivers a substantial amount of leading reactive kva into the system for power factor correction, 60 per cent of the motors full load rating; they are usually operated with the motor field set to give 80 per cent leading power factor at full load and consequently are over-excited at fractional loads, therefore delivering a larger amount of leading reactive kva at light loads than at full load or overload. This characteristic is advantageous in that even though the load on the motor-generator set drops the corrective effect is still available.

This basically is a decided advantage, particularly if we are purchasing power that has a power factor penalty clause attached, or in limiting distribution cable size to a minimum. But it also has the disadvantage in that each synchronous motor contributes materially to fault currents in the alternating current system. The question of adequate interrupting capacity switching equipment is of paramount importance. The capacity of the circuit breakers may be such that the addition of one synchronous motor-generator set may necessitate the complete replacement of all switchgear or the introduction of current limiting reactors with their associated losses.

The rectifier power factor is not subject to adjustment during operation as in the case with the synchronous motor-generator set. It is determined by the transformer connections and the transformer supply circuit constants. In general, the power-factor of the rectifier at the transformer primary is the result of the combined effects of wave distortion and wave displacement, and will be approximately 92 per cent over a large part of the load range. The rectifier does not contribute any reactive kva to the system for power factor correction, but on the other hand it does not contribute any power to a fault condition.

If higher system power factor is desired to meet purchased power company demands, or limit distribution cable sized to a minimum, it is a relative simple matter to install the necessary amount of leading reactive kva in the form of capacitors.

A direct comparison as to the relative merits of the excitron or ignitron type of mercury arc rectifier and the synchronous motor generator set is given in the accompanying tabulations, using the 1,000 kw, 250 volt d-c units, either 25 or 60 cycle, as comparison.

These are the facts that we must consider in making a definite committment in the installation of a conversion unit.

A basic knowledge of the construction and operation of the mercury arc rectifier removes the psychological obstacle.

The comparison of efficiencies shows a very decided advantage in favor of the mercury arc rectifier.

In operation and maintenance, the rectifier has the advantage in simplicity, smooth operation and cleanliness.

In the effect on the a-c power system, the use of capacitors for power factor correction places the advantage on the side of the rectifier, as it will not contribute power to fault conditions, and it does not impose abnormal demands in starting.

The first cost of the rectifier is somewhat higher than a motor-generator set, but the installation costs will be less as the foundations and structure can be lighter due to absence of vibration.

A balance of these factors shows the advantage to be on the side of the rectifier.

DISCUSSION

PRESENTED BY

W. E. GUTZWEILER, Electrical Engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

L. W. MORTON, Rectifier Application Engineer, Industrial Engineering Department, General Electric Company, Schenectady, New York

C. T. PEARCE, District Engineer, Westinghouse Electric and Manufacturing Company, Philadelphia, Pennsylvania

W. A. SMILEY, Electrical Department, Bethlehem Steel Company, Steelton, Pennsylvania

L. F. COFFIN, Mechanical Superintendent, Bethlehem Steel Company, Sparrows Point, Maryland

A. D. HOWRY, Electrical Engineer, Alan Wood Steel Company, Conshohocken, Pennsylvania

W. E. GUTZWILLER: Mr. Howry has presented in a very able manner, and in the language of the steel mill operating engineer, this most timely paper.

I would like to add a few words in regard to the basic

difference between the two available types of single-anode rectifiers, that is, the ignitron and excitron type. Both types of rectifiers are of the same general design, require approximately the same amount of auxiliary apparatus, take up about the same space, and have the same overall performance in regard to efficiency, power factor, backfire frequency, etc. They differ radically, however, in regard to their method of arc ignition.

Each type of rectifier has a main anode, a cathode (mercury pool) and an arc ignition device, all in a common vacuum tank. The load current is carried for approximately one-third of each alternating current cycle while, during the remaining two-thirds of the cycle the anode is idling.

In order that the main or load arc be properly and precisely established every cycle, sufficient electron emission from the cathode must take place at the moment the main arc is to pick up once every cycle. This electron emission has to be produced on the surface of the mercury pool forming the cathode.

In the ignitron type, this emission is produced intermittently by an auxiliary electrode called an igniter, an instant before the main anode is to pick up its load arc. This is accomplished by forcing high current impulses of short duration through the igniter electrode into the cathode synchronously with the a-c supply voltage on the main anode.

In the case of the excitron, ignition or electron emission on the cathode is established when the rectifier unit is put on the line and is maintained thereafter throughout the operating period. The ignition is started by a solenoid operated mercury spray device, spraying mercury against a fixed ignition electrode located in the center of the mercury pool about 2 in. above the mercury level. This spray momentarily connects the mercury pool with the fixed ignition anode, thereby establishing an electric circuit. When the spray disappears the circuit is interrupted, thus producing an arc which furnishes the necessary electron emission on the cathode surface. This arc is then maintained at the ignition anode as long as the rectifier is on load, and furnishes a continuous excitation or electron emission for the excitron rectifier.

The ignitron, or intermittently excited rectifier, may be compared with the operation of a gasoline engine. The ignition spark, corresponding to the current impulse through the igniter, is established in each engine cylinder, once every revolution at the proper moment, that is, when the compression of the gas mixture has reached its maximum value.

The continuously excited, or excitron type rectifier, may be compared with an automatically controlled gas burner, where the main burner is ignited by a continuously burning pilot light, whenever heat is required, the pilot light corresponding to the arc on the ignition anode of the rectifier.

L. W. MORTON: The installation of rectifiers in steel mill service has been rather rapid since 1937. There are, I believe, more than 30 rectifiers installed, totalling more than 35,000 kw.

There are many reasons for this acceptance. They have proved reliable in service from the outset. The mystery which has surrounded the rectifier has been dispelled. I think this is largely because steel mill engineers have carefully studied rectifiers and learned to understand them. Mr. Howry's paper is a convincing example of this study.

There is one interesting point that Mr. Howry mentioned in his paper that I have not heard before; that is the effect of the rectifier on the system short-circuit capacity. When the system has grown to the point endangering the interrupting capacity of the older installed a-c breakers, addition of more synchronous conversion capacity may be the straw that breaks the camel's back. Adding rectifiers does not influence the short circuit capacity of the system, and the old breakers still remain safe. This point may be such an important factor that it outweighs the occasional disadvantage of power factor, a disadvantage brought forth in the paper.

Another very interesting part of the paper dealt with the dollar figures. There is a lack of information dealing with maintenance and savings, and it is hoped that further material of this sort will be forth-coming as more and more experience is gained.

Finally, I would like to stress what I think is an extremely important point. That is the question of copper savings. Mr. Howry stated that "an analysis of a system may show that the load centers are remote from the generation source, and that certain economies of distribution must be considered before additions are made." Usually increasing the capacity of an old d-c substation simultaneously requires more 250-volt distribution copper. Rectifiers are particularly suitable for location at the d-c load centers. The rectifier has small need for operating supervision. It is adaptable for installation almost anywhere in the plant, even when regular employees are at work. Then too, freedom from special foundation requirements facilitates placement at the d-c load center. This means the a-c power may be brought to the d-c load center on small conductors, at high voltage. Another factor is that the rectifier equipment itself requires only about 80 per cent of the copper and 50 per cent of the steel in its construction that rotating conversion apparatus does. But the latter saving is small compared with the copper savings in the 250 volt power distribution system made possible by load center placement of the rectifier.

Furthermore, the opportunity of distribution system copper saving has been widened by the increased range of rectifier rating now available. The d-c load center requirements may be small — less than 500 kw. While continuously evacuated type rectifiers described by Mr. Howry are very suitable above 500 kw, below 500 kw the necessity of constant pumping complicates an otherwise smaller equipment. Sealed-off type rectifiers have been developed and proved by service, extending down into ratings from 500 kw, at 250 volts. They are even simpler in operation, easier to install, and more suitable for location out around the plant than their larger pumped-type counterparts. A wide acceptance — over 100 such units — has occurred. Such rectifiers also merit thoughtful consideration.

C. T. PEARCE: The mercury arc rectifier as I visualize it, differs from the rotating machinery form of conversion primarily in two respects; one, it is basically a current device, and secondly, it is static. Most of the differences in operation and usage stem from those two things. The fact that it is a current device means that its losses are primarily the same percentage of load

from no load to full load, so that you get a relatively level efficiency curve. Constant losses occur only in the transformer and auxiliaries. The fact that it is a static device means you have no commutator and that, in itself, probably explains to a great extent why the maintenance is lower. Moreover, the absence of a commutating device means you can carry much greater overloads, at least momentarily, as the speaker has already brought out.

I am not giving you anything new; but I thought these points might be worth emphasizing; and that is why mercury arc rectifiers found first application in railways because traction loads vary from a small amount of power up to tremendous swings and this is a place where the rectifier fits the whole range of loads very nicely.

Another thing I might say is, the fact that it is a current device means it is still more advantageous at higher voltages; 250 volts is in the great majority in steel mills. The loss for a given current is substantially the same, whether for 250 volts or 600 volts, and it was only after the advent of single tank devices, such as the ignitron and the excitron, that it was possible to space the anode and the cathode sufficiently close together where they can compete properly from an efficiency standpoint with rotating devices and particularly the rotary converter, which is more efficient than the motor-generator set.

W. A. SMILEY: In connection with Mr. Howry's paper, there is a thought I would like to add to what he has already given you, with particular regard to the relative costs of motor generator sets and mercury arc rectifiers.

About a year or more ago, we installed 1500 kw of 12 phase rectifiers. At that time we considered motor generators, rotary converters and mercury arc rectifiers, and found that there was a large difference in first cost between the motor generator and the mercury arc rectifier, favoring the rectifier. Wherein this difference lay, can be best illustrated by taking a somewhat more extreme case. Supposing we require 300 kw direct current, to be derived from an 11,000 volt line — it might be that we could wind a motor for 11,000 volts, to drive a 300 kw motor-generator set, but the more likely solution would be to put in a step-down transformer bank.

So, having to purchase a transformer, whether we use the motor-generator set or the mercury arc rectifier, the cost of the mercury arc rectifier will usually be the lesser, and as Mr. Morton pointed out, there is the big factor in the saving of copper to be considered, particularly where you are able to disperse your d-c load centers, using smaller units and working them from high tension lines.

L. F. COFFIN: I would like to ask whether there is not, in the ignitron, a gradual slow loss of mercury and if so, what is the rate of loss?

A. D. HOWRY: The rectifier being a sealed unit, the gasifying and condensing of mercury is just a complete circulation or cycle, you might say. There is no loss of mercury. Any possible mercury loss we may have in the rectifier would be in the vacuum system where we have a mercury pump, and a slight amount of mercury loss may occur at this point. Possibly Mr. Gutzwiller can explain this in more detail.

W. E. GUTZWILLER: In answer to the question as to whether mercury is consumed in the process of rectification, the following may be said:

In the normal process of rectification, mercury is evaporated by the heat of the arc at a high rate. The mercury vapor condenses on the water cooled walls or internal cooling coils of the rectifier, and the mercury returns by gravity to the cathode through a mercury filtering system. There is no loss of mercury in this process.

In case of pump evacuated mercury arc rectifiers, there is, however, a possibility of mercury vapor being drawn out of the rectifier tanks by the vacuum pump. This may happen if the rectifier is not properly cooled, is subjected to excessive overloads, or if the temperature control devices do not function properly. An excessive amount of mercury transfer to the mercury vapor pump in the form of vapor may eventually flood this pump and prevent its proper functioning. In all modern rectifier designs provisions are made to reduce this mercury transfer to a negligible amount. It is also advisable to have the mercury vapor pump checked at intervals of one to two years, in order to determine the amount of transfer, and if necessary, remove any excess of mercury before it causes operating difficulties.

STEINERT and REDDIE DISCUSSION

(*Continued from page 51*)

won't have to go to unusual construction. We never did on d-c machines and I doubt if we will on a-c machines.

J. H. COOPER: While we thoroughly agree as to all advantages of a-c arc welding and have purchased several hundred machines for one of our Warren plants, we also recognize that the use of these machines is made possible by adequate positioners to permit welding in down-hand position only, and no vertical or over-head welding. Of course, there have been a number of claims that a-c welding in vertical and over-head position can be done. Under certain conditions, with well trained men, this is true. On the other hand, for a normal group of welders, it is not so. In our opinion, the use of a-c welding should be largely limited in production to the conditions under which we use it, and have described it. The use of alternating current with carbon pencils is also out of the question. It is not practical to use it with electrodes with definitely reversed polarity characteristics, and in many cases, it is very desirable to use electrodes having such characteristics.

C. H. JENNINGS: Satisfactory welds can be made in the vertical and overhead positions with a-c welding machines. Comparative tests made in the flat, horizontal, vertical and overhead positions with a-c and d-c machines indicate essentially no difference in tensile strength, ductility, deposit efficiency and melting rate providing an electrode designed for a-c is used. X-ray tests generally indicate that a-c produces sounder welds.

Production welds are made every day in the vertical and overhead position with a-c machines and the results are very satisfactory. The reduced arc blow obtained with a-c generally makes faster and higher quality welding possible than is the case when d-c is used.

Until recently, the welding industry did not have an electrode for a-c comparable to the A. W. S. E-6010 electrode which is a straight polarity d-c electrode. At the present time, however, such electrodes are available.

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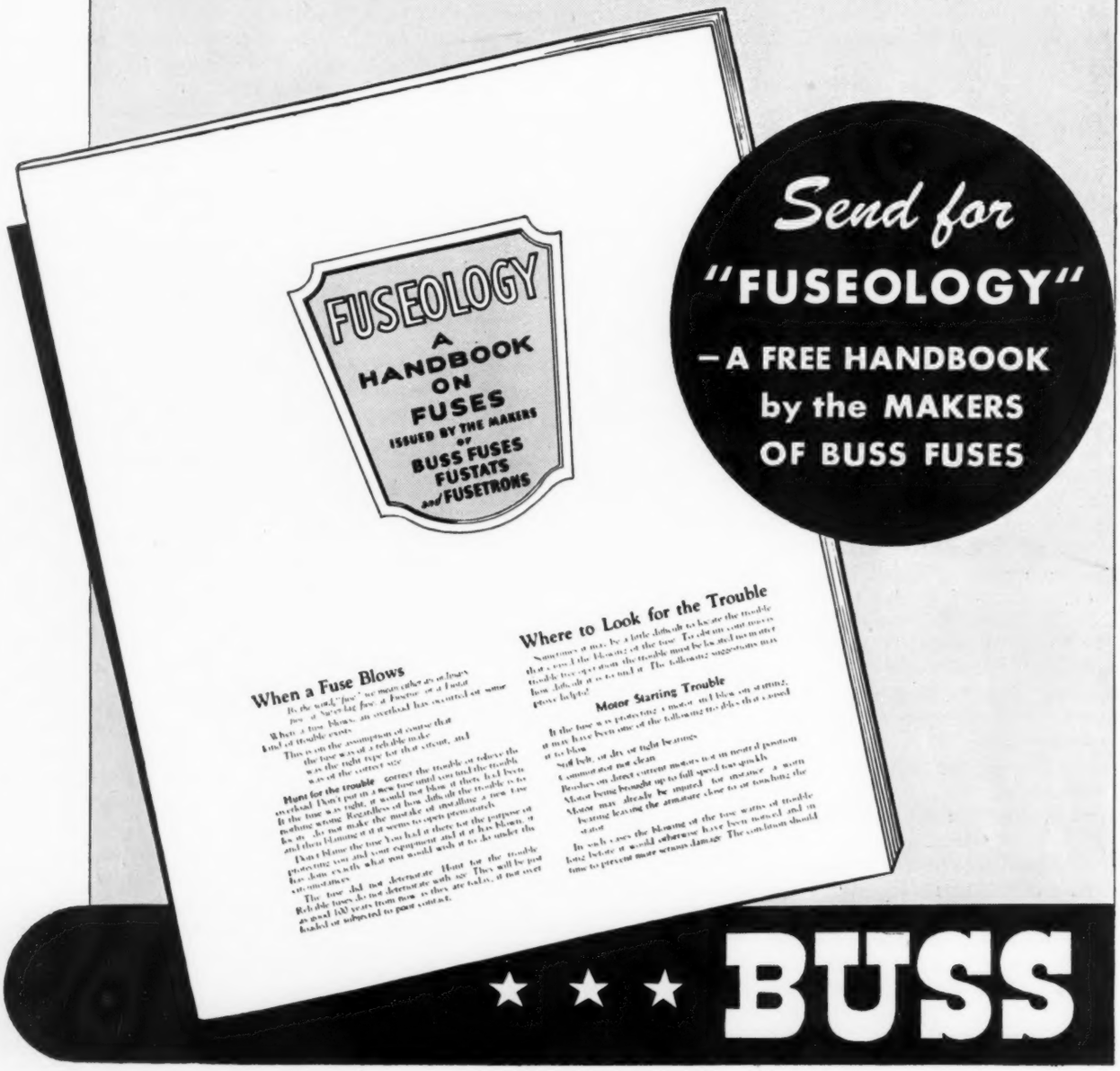

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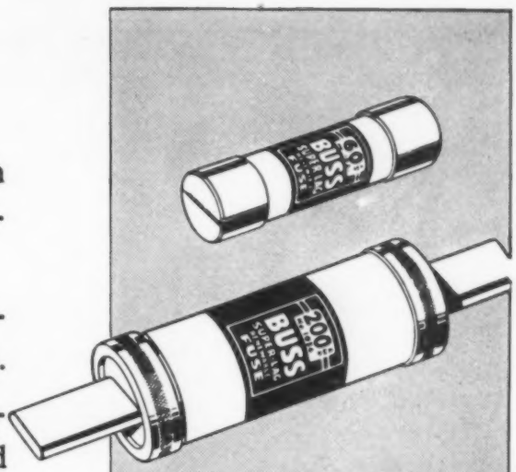

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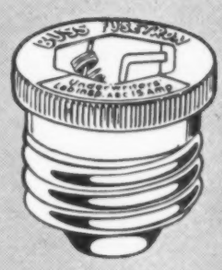

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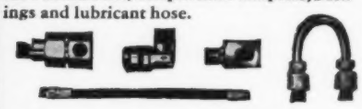

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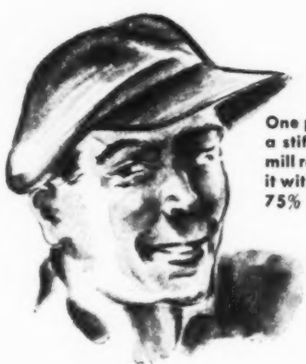

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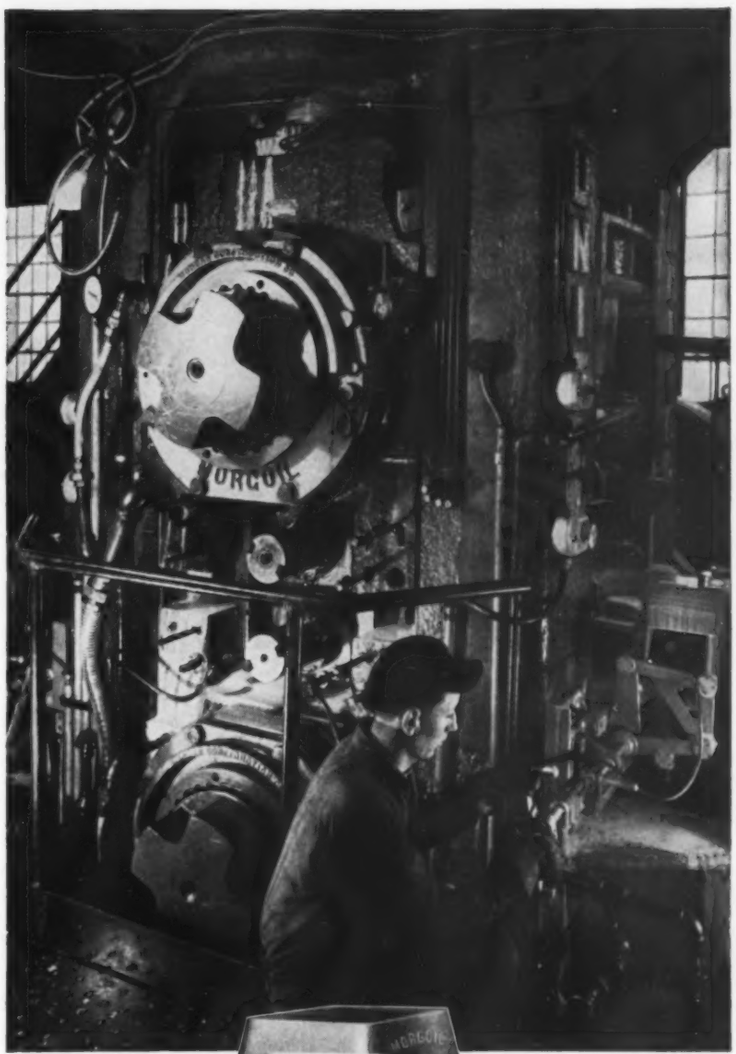

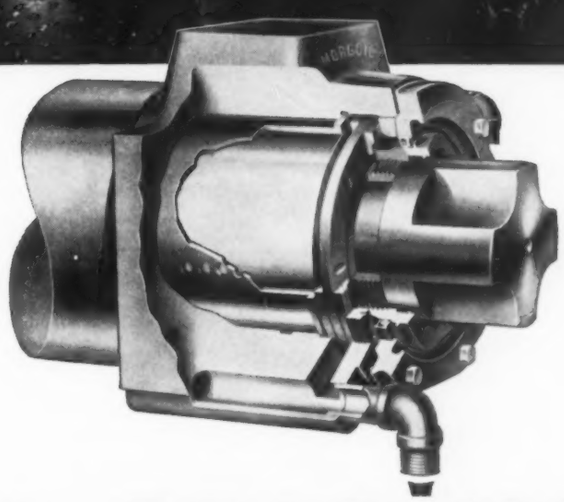

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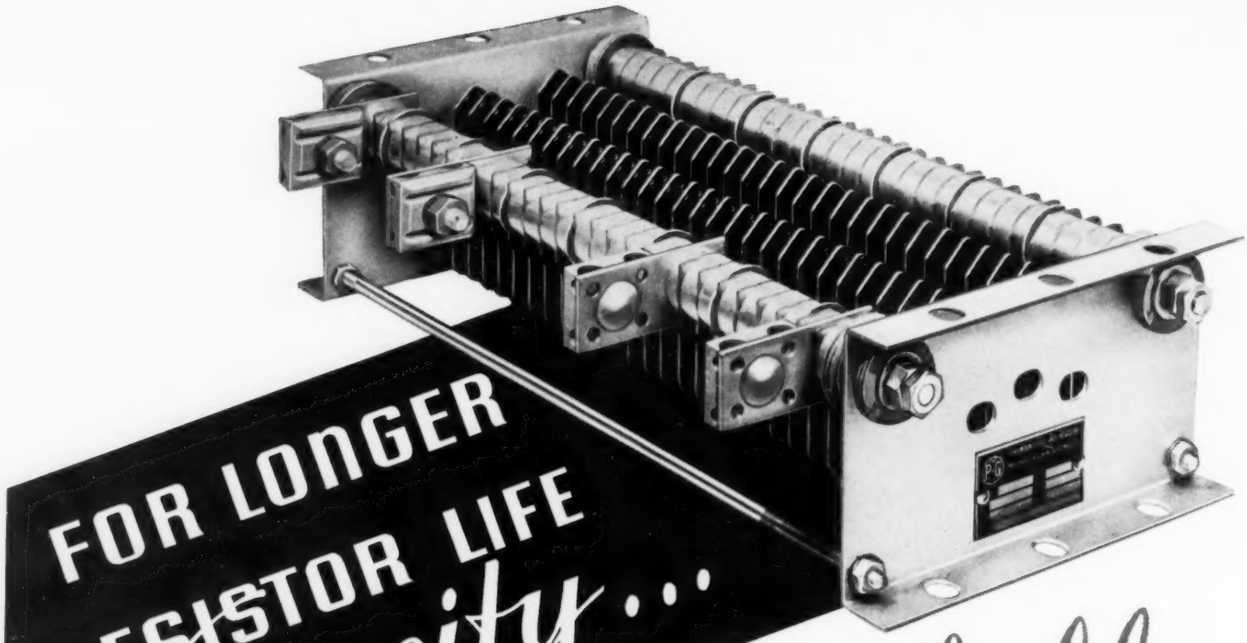

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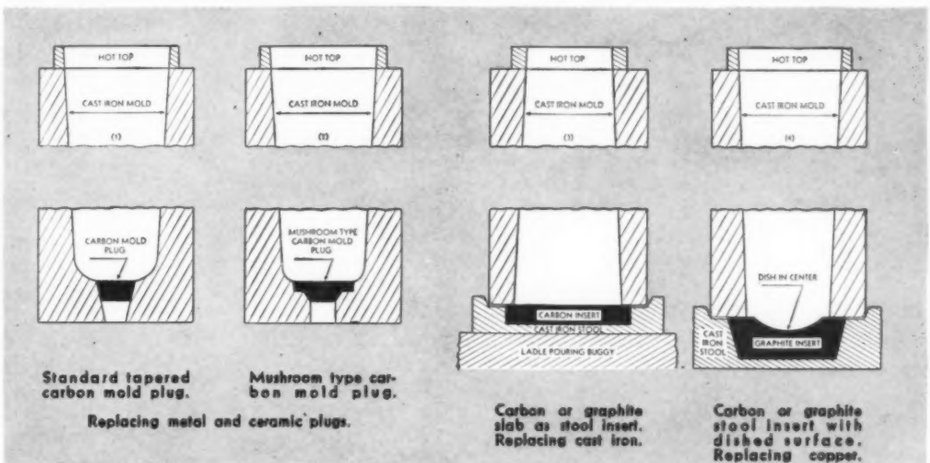


Standard tapered carbon mold plug. Mushroom type carbon mold plug. Replacing metal and ceramic plugs.

Carbon or graphite slab as stool insert. Replacing cast iron.

Carbon or graphite stool insert with dished surface. Replacing copper.

Graphite pouring block. Replacing cast iron and steel.

Solid carbon stool. Replacing cast iron and steel.

"National" Carbon, Graphite and "Karbate" products are successfully meeting many mechanical, electrical and chemical requirements in the metallurgical and process industries. They are available in many sizes and shapes, such as brick — beams — blocks — pipe, fittings and valves — for the fabrication of tanks — tank linings — pipe systems —heat exchangers— towers and other equipment for handling or processing corrosive materials. Write for complete information.

are important advantages offered by these materials in such applications as ingot mold plugs, stool inserts, stools and pouring blocks (see sketches of typical applications). Mold and stool life have been prolonged and other economies made possible.

STANDARD TAPERED MOLD PLUGS

Standard tapered mold plugs are available in two sizes:

$5\frac{13}{16}$" x $5\frac{1}{4}$" x 3"

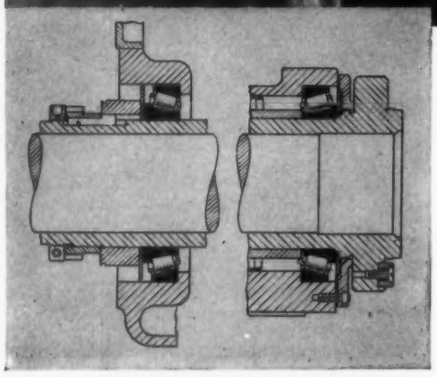
$5\frac{15}{16}$" x $5\frac{9}{16}$" x 3"

Other sizes and shapes of mold plugs, as well as stool inserts, stools and pouring blocks can be supplied to meet any desired specification.

The words "National" and "Karbate" are trade-marks of National Carbon Company, Inc.

NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC
CARBON PRODUCTS DIVISION, CLEVELAND 1, OHIO
General Offices: 30 East 42nd St., New York, N. Y.
Branch Sales Offices: New York - Pittsburgh - Chicago - San Francisco

IN THE NEWS
WITH TORRINGTON—BANTAM



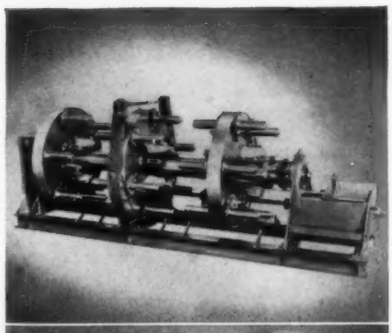
HAIR-BREADTH PRECISION WORK at high speeds is being turned out with turret lathes such as this to help win the battle of production. Built by Gisholt Machine Company, this lathe employs Ultra-Precision Tapered Roller Bearings on the spindles (see cross-section) as an aid in maintaining extreme accuracy. The eccentricity and face run-out of these bearings is .0002 maximum—an outstanding example of the ability of Bantam Bearings Division to build precision bearings for heavy-duty applications.

NEEDLE BEARINGS— ALL TYPES—ALL SIZES

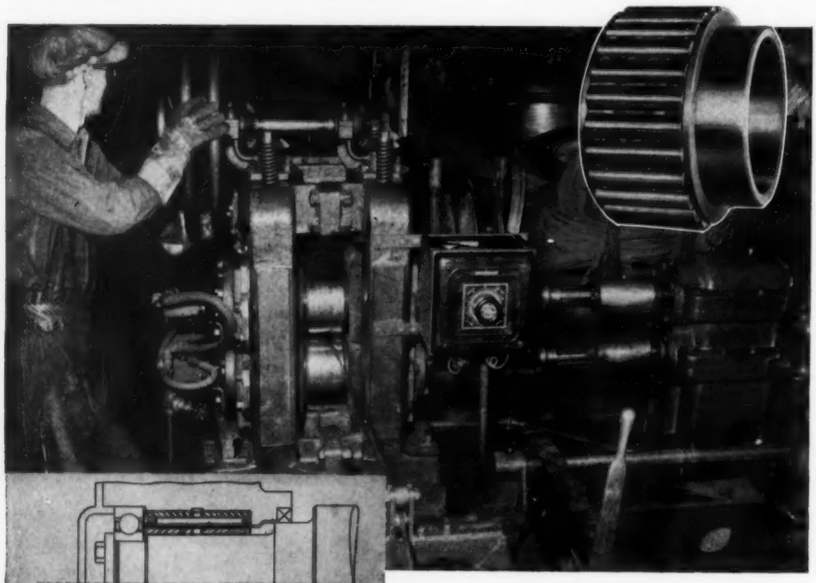
NEEDLE BEARINGS TYPE DC are complete, self-contained units consisting of a full complement of rollers and a drawn, hardened outer race. They offer the advantages of small size, low cost, high capacity—and easy installation.

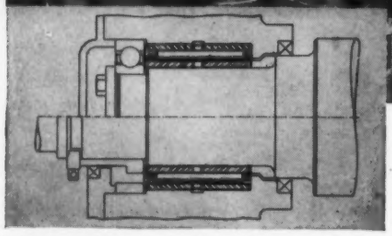
NEEDLE BEARINGS TYPE NCS consist of a full complement of rollers and a relatively heavy hardened outer race. They are furnished with or without inner races. Needle Bearings Type NCS are adaptable to heavier loads than Needle Bearings Type DC.

NEEDLE ROLLERS TYPE LN are produced in a range of types and sizes for assembly into low-cost, high-capacity anti-friction bearing units. Our engineering department will make recommendations as to correct size and type selection.



ROTATING 650 POUNDS OF WIRE AT 120 R. P. M. requires spindles of exceptionally high load capacity in wire stranding units built by The Watson Machine Company. Dependability in the main sheave bearings under this severe strain is assured by the use of Ball Radial Bearings. Designed and built by Bantam Bearings Division, these bearings have withstood years of such service without a single replacement.





HIGH CAPACITY in a small space is provided by straight radial roller bearings in this 8-inch flattening mill built by Broden Construction Company, while ball bearings, also designed by Bantam Bearings Division, take the thrust load. The bearing arrangement, shown in cross-section, permits compact design.

TORRINGTON BEARINGS

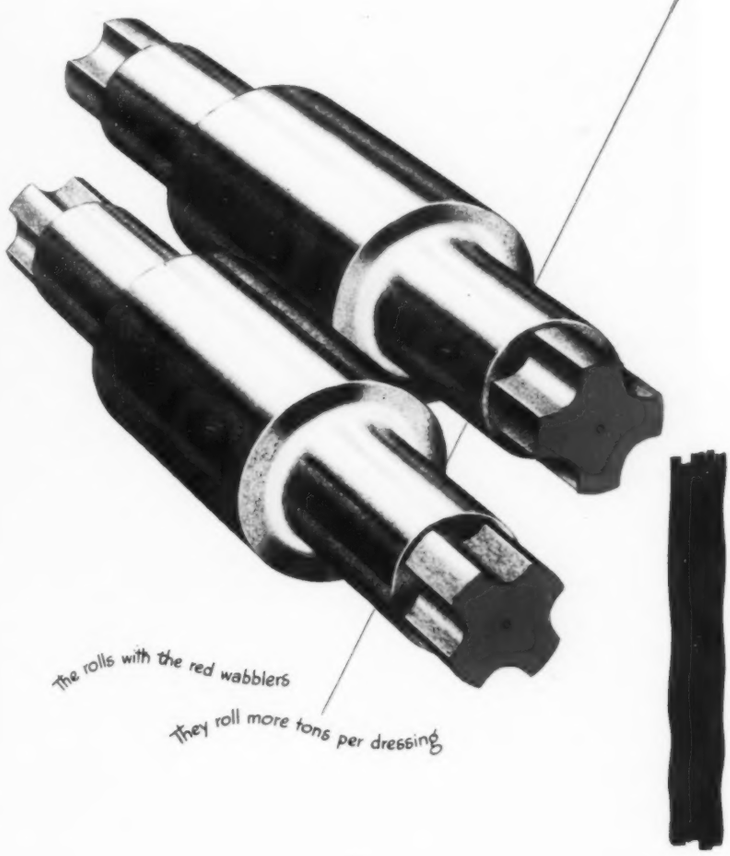
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA

Ol' Red Wabbler says:

Hytensite Rolls have the strength of steel...

The wearing and finishing properties of cast iron



The rolls with the red wabblers

They roll more tons per dressing

The M-H Hytensite Rolls are high test alloy cast iron, specially treated. They contain appreciable proportions of visible graphite finely and uniformly distributed throughout, with a corresponding uniformity of structure of wearing and finishing qualities. They have a tensile strength of 60,000 to 100,000 lbs. per sq. in., with hardness of 50 to 70 Scl. (C scale). They are cast iron, and as such are free from the deleterious "notch effect" of steel. Small radii in the neck fillets and various passes, do not adversely weaken the roll.

You can have these extra qualities built into Mackintosh-Hemphill rolls — specify M-H Hytensite Rolls on your next order for finishing stands of Merchant Mills, Sheet Bars and Billet Mills.

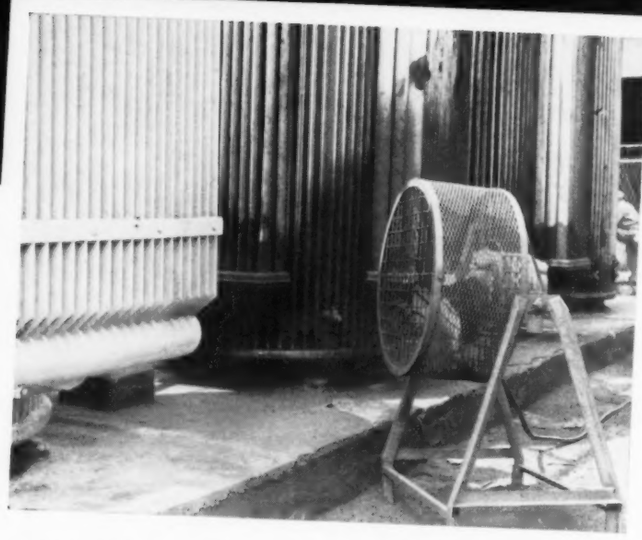
Other Mackintosh-Hemphill Products:
Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers . . . Pinions . . . Special Equipment . . . Iron-Steel Castings . . . The NEW Abramsen Straightener . . . Improved Johnston Patented Corrugated Cinder Pots and Supports . . . Heavy Duty Engine Lathes.

MACKINTOSH-HEMPHILL COMPANY—Pittsburgh and Midland, Pa.

Let Truflo Fans . . .

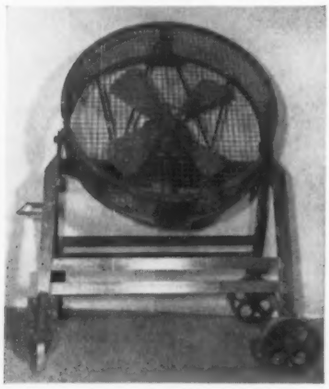
Help keep your workmen on their toes

Portable Fan No. TF-100, recognized as standard in many of the country's largest mills. Sizes from 12 in. to 36 in. in diameter.



Portable Fan No. TF-300 in operation, cooling large transformers in strip mill.

Crane Cab Fan, for cooling crane cab interiors and other confined areas. Available in 12 in. and 18 in. sizes, adjustable both horizontally and vertically.



Portable Fan No. TF-300W. Angle iron support adjusts for vertical or horizontal discharge through almost 360°.

It's more important now than ever before to keep your workmen comfortable. For comfortable workmen are more efficient, produce more work in a given time.

Truflo Fans can help you keep your workmen on their toes. All Truflo Fans are designed and built correctly for efficient, economical operation — they move more air per dollar. Write for free literature on any of the following styles:

Portable Cooling Fans • Crane Cab Fans
Wall Fans • Exhaust Fans • Blowers
Roof Ventilating Fans • Pent House Fans

TRUFLO FAN COMPANY

554 MAIN STREET HARMONY, PA.

Left—Type A Safety Switches 2, 3 and 4 pole; 30, 60, 100, and 200 amperes; 125, 250, and 600 volts; fusible type. Without interlocked receptacle for QuelArc plug.
Right—Safety Switch with interlocked QuelArc plug receptacle.

Heavy-Duty Safety Switches and Circuit Breaker Pylets

BUILT FOR MILL AND RAILROAD SERVICE

Circuit breaker Pylet with interlocked receptacle and QuelArc plug.

Pyle-National safety switches have the substantial construction needed to withstand severe operating conditions. The case and cover are heavy-section galvanized cast iron; operating parts are of heavy cast metal, and are designed for quick make and break action. Contacts are mounted on heavy slate. The operating shaft has bronze bearings. The case is fully protected, with both cover and hub plates equipped with weatherproof gaskets. The operating lever extends through the case in a rustproof bearing, and the cover is held closed by rustproof wing nuts and bolts. These features assure dependable service and long life even under severe operating conditions.

Circuit breaker Pylets are of similar heavy duty construction, and are available with or without interlocking receptacle for QuelArc plugs.

Write for Pylet general Catalog 1100 with complete listings.

PYLE-NATIONAL
ELECTRICAL EQUIPMENT
• SINCE 1897 •

THE PYLE-NATIONAL COMPANY
1334-58 North Kostner Avenue
Chicago 51, Illinois
Offices: New York, Baltimore, Pittsburgh, St. Louis, St. Paul, San Francisco

CONDUIT FITTINGS • FLOODLIGHT PROJECTORS

LOCOMOTIVE ELECTRICAL EQUIPMENT

AMERICAN STEEL AND WIRE BREAKS MANY RECORDS

▲ The first six months of 1943 saw more production records established throughout the plants of American Steel and Wire Company, a U. S. Steel subsidiary, than ever before in the company's history. The total number of new records established soared to 431 for the six month period bringing the number of old records broken since Pearl Harbor to 1373.

Outstanding during the first half of the current year was South Works, at Worcester, Massachusetts, which smashed 157 records. North Works added 37 new highs to bring the total for the Worcester operations of the company to 194. The Donora (Pennsylvania) Steel and Wire Works broke 60 former records, while the Joliet, Illinois, operations established 39 new highs. The Cleveland, Ohio, plants contributed 65 new marks, Cuyahoga Works establishing 19 of them, Consolidated Works making 15, American Works 16, Newburgh Wire Works 7, and Central Furnaces 8. The New Haven, Connecticut, plant established 25 new highs, while Trenton, New Jersey, broke 22 former records. Waukegan, Illinois, and Duluth, Minnesota, operations each set 12 new highs, while the Allentown, Pennsylvania, plant established 2 new records.

NEW FURNACE BOOSTS PIG IRON CAPACITY

Pig iron production in Pittsburgh's war-busy "Victory Valley" soars to new heights as the Carnegie-Illinois Steel Corporation begins producing metal in one of the world's largest blast furnaces erected for the government's Defense Plant Corporation at the company's Edgar-Thomson Works in Braddock. The additional iron supply is a big boost for the War Production Board's campaign to obtain two million extra tons of fighting steel from American mills in the last half of 1943. This picture shows the first molten iron being cast from the giant new "C" furnace at this U. S. Steel plant. Her operation adds 1330 net tons of pig iron to the district's already record-breaking daily output.

ASHLAND FURNACE BREAKS OWN RECORD

▲ Although steel workers insist all blast furnaces are "ladies," here is one that has gone on a two months' spree.

Bellefonte, big blast furnace of The American Rolling Mill Company, at Ashland, Kentucky, has the neighbors talking about the way she has been roaring, night and day.

In May she set a new production record. Everyone thought that would calm her down. It didn't. In June, Bellefonte's wind was as good as ever. She ignored all the gossip and although old timers shook their heads, Bellefonte crashed through with another production record in June, topping the May peak by 150 tons in spite of the fact she had to do more in 30 days than in 31.

Robert S. Gruver, manager of the Ashland Division of Armco, announcing the second consecutive production peak, revealed that the furnace had also twice broken weekly production records during June and had established a new high average production per day.

This ROCKBESTOS *PERMANENTLY INSULATED CONSTRUCTION*

(and more than 120 others)

assures long-lived wire performance

. . . and Here's How

1 A tough, rugged, smooth-finished asbestos braid impregnated with heat, flame and moisture resistant compounds to make a non-deteriorating, heatproof, fireproof jacket, highly resistant to oil, grease, moisture and corrosive fumes.

2 Outer felted asbestos insulation impregnated with heat, flame and moisture resisting compounds. Acts as a heat-barrier against high ambient temperatures.

3 Lubricated varnished cambric for high dielectric strength and high moisture resistance, protected from heat, flame and oxidation between two felted asbestos walls.

4 Dense felted asbestos insulation impregnated with heat, flame and moisture resisting compounds will not dry out, bake brittle or crack with vibration. Withstands conductor-heating overloads and won't burn even when exposed to copper-melting arcs.

5 The conductor is *perfectly* and *permanently* centered in helically applied insulation that stays put and will not migrate or flow under the action of heat, oil, grease, etc.

RESISTS moisture, oil, grease and fumes
WON'T bake brittle, burn, flow or rot

Rockbestos A.V.C. Power Cable—600 to 5,000 Volts—
No. 18 A.W.G. to 1,000 MCM
Underwriters' and N.E. Code, Type AVA—maximum operating temperature 110° C.

Permanently insulated Rockbestos A.V.C. wires, cables and cords, developed for trouble-free operation under severe operating conditions such as in circuits that run around steel mills, soaking pits, hot forging presses, boilers, steam tunnels, etc. are available in a wide range of sizes and types. Special wires for unusual applications will be designed to meet your requirements. Rockbestos Research will gladly assist you in the selection of the right wire for that difficult wiring problem. Write nearest branch office or:

Rockbestos Products Corp., 905 Nicoll St., New Haven, Conn.

for VICTORY invest in War Bonds

ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, ORE.

LUBRICATION SYSTEMS FOR MACHINE TOOLS

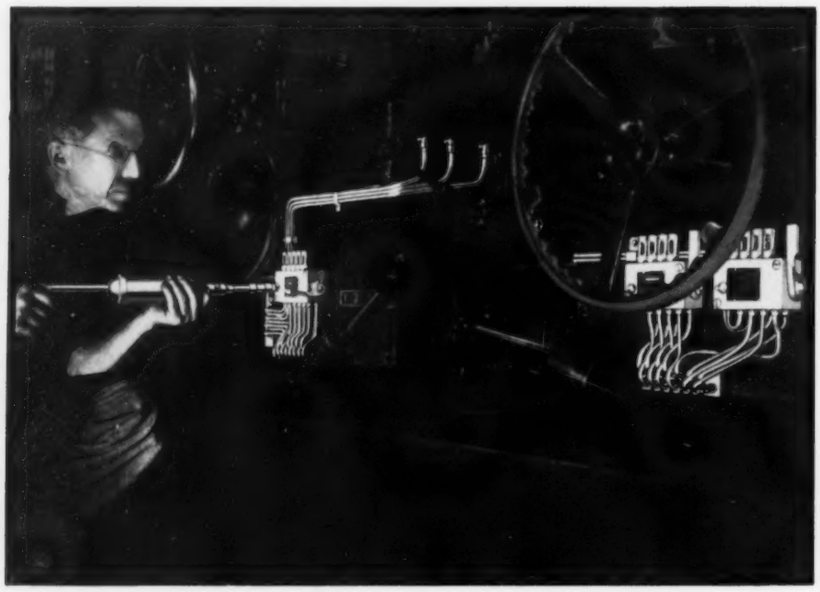
▲ Positive lubrication of all bearings on machine tools and similar equipment, regardless of location or condition of bearings, can be had through the improved "Multival" system made by the Farval Corporation, Cleveland. Oil or grease under pressure is delivered to the distributing blocks by means of a manual or power-operated portable gun which serves as a central pump.

Complete multival equipment consists of the multiple valve blocks each serving 2 to 10 bearings, lubricant lines leading to individual points, and suitable fittings to accommodate practically any type of bearing connection. The systems can be readily installed by shop maintenance crews.

Each measuring valve can be individually adjusted to deliver the exact amount of lubricant required by the bearings it serves. A tell-tale on each valve piston indicates the positive delivery of lubricant to each bearing. With blocks mounted at accessible points on the machine the operator lubricates all bearings with complete safety while the equipment is in full operation — and not a bearing is missed.

Experience shows that the multival system will reduce labor of oiling, eliminate waste of lubricant, increase production, reduce repairs and maintenance and prolong the life of tool equipment.

Multival systems permit lubrication of a machine without stopping operation. Each measuring valve can be individually adjusted for the exact amount of lubricant required by the bearing it serves.



ELECTRIC FURNACE CAPACITY RAISED BY NEW UNIT

Adding 65,000 tons annually to the nation's capacity for the production of aircraft steels, a new electric furnace has been placed in operation at the South Chicago Works of Carnegie-Illinois Steel Corporation, United States Steel Corporation subsidiary. Addition of this new furnace brings to six the number now in operation in the plant's electric furnace department, which has been for many years U. S. Steel's principal producer of electric furnace steels.

The new furnace, designed and installed by another U. S. Steel subsidiary, American Bridge Company, is now in full production, turning out 70 tons per heat of steel. Installation was begun in October 1942, and completed early this month. Electric power for the new furnace is supplied from the plant's own generating stations.

Electric furnace steels are used in the aircraft industry for the manufacture of parts for engines, flying instruments, propellers and landing gears. They are also used in a number of critical airframe parts and accessories. Stainless steel made in electric furnaces also is used in many military aircraft parts. Principal peacetime uses of electric furnace steels are in the oil, machine tool, aircraft and automotive industries. One of the most important uses is for the manufacture of anti-friction bearings. Stainless steel made in electric furnaces also has played an important part in the building of many streamlined trains and has been used in the manufacture of truck and trailer bodies.

RULES FOR MAGNET CARE

▲ Thirteen suggestions proved by experts, in simple clear language with graphic pictures telling just what to do and what not to do — this is given on an 8 in. by 20 in. card to be hung in the magnet crane cab.

Because every pound of iron, steel and copper is vital, because every speed-up in handling and production will shorten the course of this war, lifting magnets should be handled carefully to preserve them, yet expertly to get the utmost out of them. That is why Cutler-Hammer had prepared this card.

This is a free Cutler-Hammer contribution to the common cause of speeding production and conserving critical material and manpower. If you want a sample or supply simply address Cutler-Hammer, Inc., 259 No. 12th Street, Milwaukee 1, Wisconsin.

POWERED WITH PHILCO "XL" BATTERIES,
YOUR MOTORIZED HAND LIFT TRUCKS
HAUL 10% MORE MATERIAL!
In a constantly increasing number of plants from coast to coast, *battery-powered hand lift trucks* are doing a tremendously successful job in the field of materials handling!
For every make and every model, Philco offers a rugged, dependable battery specially engineered for heavy-duty motive power service!
Powered with Philco "XL" Batteries, motorized hand trucks haul 10% more material! Plate for plate, you get 10% greater capacity in a Philco . . . with extra wallop and sustained high voltage, hour after hour!
Get the facts on Philco Batteries for motorized hand lift trucks. In every important industrial center from coast to coast there's a Philco representative ready to serve you.
PHILCO CORPORATION
STORAGE BATTERY DIVISION
TRENTON 7, NEW JERSEY
SPECIFY RUGGED
PHILCO
BATTERIES
PHILCO

COTTON BELT SPLICING

▲ As a contribution to the war production program, the Westinghouse Electric and Manufacturing Company has opened a school to teach men from other industries the secrets of a cotton belt splicing technique that has already saved thousands of dollars worth of time and materials in the construction of war equipment. The use of this technique in Westinghouse plants, officials said, has increased the efficiency of machinery and released war-scarce leather and rubber for other uses. It also resulted in a savings of $12,000 the first year of its operation. Even greater savings have been realized since.

The patented method, developed by a veteran Westinghouse workman, is being offered without charge to other companies for the duration of the war.

This process is being made available to other concerns in line with a request of the Army's Bureau of Ordnance which sought "not only new developments but ideas already reduced to practice that we can pass on to others doing similar work." This process sharply cut down the time machines were idle for belting repairs.

Among those on hand for the opening of the school at the Westinghouse Manufacturing and Repair Plant in Homewood were students from the Jones and Laughlin Steel Corporation, the Auburn Spark Plug Company, Auburn, New York, and the Pyle-National Company, Chicago, Illinois.

Until 60-year-old Max Kholos, a Westinghouse employe for 27 years, turned a routine job into a research investigation, there was no practical method of cutting and splicing the cotton belts used on many machines. The belts had to be ordered to fit each machine or cut and sewed to size, an unsatisfactory method. Kholos overcame this difficulty and for his work was rewarded initially with a $1200 check and a patent on the method. Westinghouse acquired the patent rights for the duration of the war so that the process might be given to other companies.

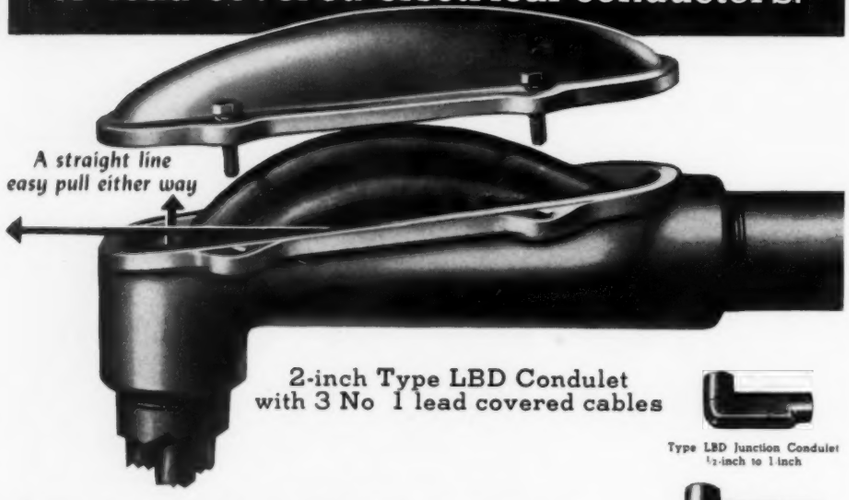
Kholos spends much of his time teaching the technique to maintenance men from other Westinghouse plants and to employes of some other companies. The school was established to provide a centralized location for this instruction. Other schools will be set up later in Westinghouse Manufacturing and Repair Plants from coast to coast.

EXTRUSION PRESS HAS GOOD FEATURES

▲ Extruded tubes of uniform wall thickness are produced without frequent readjustments of tools and machinery parts as the result of design features employed by the Schloemann Engineering Corporation, 1150 Empire Building, Pittsburgh, Pennsylvania. Extrusion presses built by this company utilize a distinctive method of supporting the platen and container holder in the centerline of the container. This simple and reliable method permits expansion and contraction of platen and container holder in all directions without losing alignment with the centerline of that part of the machine which carries the press stem and remains cold. In this way, the adjusted central position of the press will be maintained, thus resulting in uniform wall thickness.

CROUSE-HINDS

Originator of the **straight line pull** type of junction **Condulet** for large or lead covered electrical conductors.



2-inch Type LBD Condulet with 3 No 1 lead covered cables

Type LBD Junction Condulet ½-inch to 1-inch

Type LBD Junction Condulet 1¼-inch to 2-inch

Type LBD Junction Condulet 2½-inch to 6-inch

Type LBH Explosion-Proof and Dust-tight Junction Condulet ½-inch to 3-inch

- **A straight line pull** through either hub. Saves time.
- **Unobstructed pulling space.** Easy to manipulate conductors.
- **Domed cover.** Provides extra space to prevent sharp bends that are likely to injure conductor insulation or sheath.
- **Gaskets** can be furnished. They make the condulet vaportight and raintight.
- **13 sizes.** For ½-inch to 6-inch conduit.
- An **Explosion-proof** type available. Type LBH in 8 sizes, ½-inch to 3-inch.

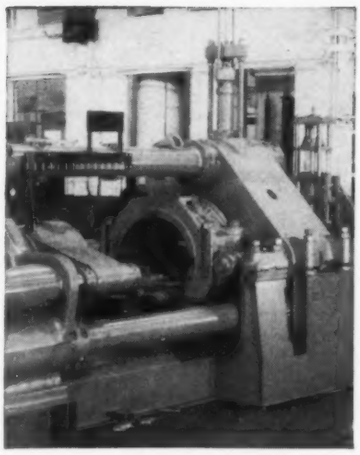
CONDULETS, manufactured only by CROUSE-HINDS, are the Standard of Quality in the field of electrical conduit fittings.

A Nationwide Distribution Through Electrical Wholesalers

CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U.S.A.

Offices: Birmingham—Boston—Chicago—Cincinnati—Cleveland—Dallas—Denver—Detroit—Houston—Indianapolis—Kansas City—Los Angeles—Milwaukee—Minneapolis—New York—Philadelphia—Pittsburgh—San Francisco—Seattle—St. Louis—Washington
Resident Product Engineers: Albany—Atlanta—Charlotte—New Orleans

CROUSE-HINDS COMPANY OF CANADA, LTD. Main Office and Plant: TORONTO, ONT.



The illustration shows that the fundamental idea of supporting platen and container holder laterally at the centerline of the container is carried logically to the support of the container itself. The container carries keys laterally which engage keyways in the housing and so enable the housing of the container also to expand evenly. The entire design thus effected minimizes readjustments.

NEW METER MEETS EXACTING TESTS

▲ The Republic Flow Meters Company announces a new boiler meter which has been subjected to very exacting field tests. This steam flow-air measuring instrument consists of an electric recording and integrating steam flow element combined with an oil-sealed bell type recording air flow meter. The two recordings, made on a 12 in. chart simultaneously, show the steam flow from the boiler and the rate of air flow to the furnace for combustion.

Regardless of the load carried by the boiler, when the furnace is receiving the proper amount of air for maximum combustion efficiency, the air flow pen recording in blue coincidentally with the red steam flow pen, gives the operator an all's-well picture, read at a glance, accurate and complete in its fact coverage. Conversely, when operating conditions are not right, this new quickly-read meter immediately guides the operator to proper adjustments.

A third pen, recording flue gas temperature or steam pressure, can be added to the Republic boiler meter so as to provide complete boiler performance information on the same 12 in. chart. This new meter may be either wall mounted or flush mounted on a steel panel. Republic meter bodies are available in a series of models to cover all ranges of differential and line pressures.

The company claims nine impressive features and advantages for this new instrument: (1) A direct-reading recorder; (2) A continuous, direct-reading, watt-hour type of steam flow integrator, having a cyclometer type, easy-to-read dial; (3) An adjustable zero-setting feature that eliminates need for exact mercury content in steam meter body; (4) A ratio adjustment to accommodate steam flow-air flow changes; (5) Adjustable cam screws permitting adjustments of air flow readings at each chart point; (6) A provision for easy field, full range adjustments of air flow meter (½ in. to 5 in. of water); (7) Completely sealed oil chamber provided by the single bell design; (8) Exceptionally high operating power provided by the oversized bell; (9) Great simplicity in design and the easy unit removal of the complete mechanism make for trouble-free maintenance.

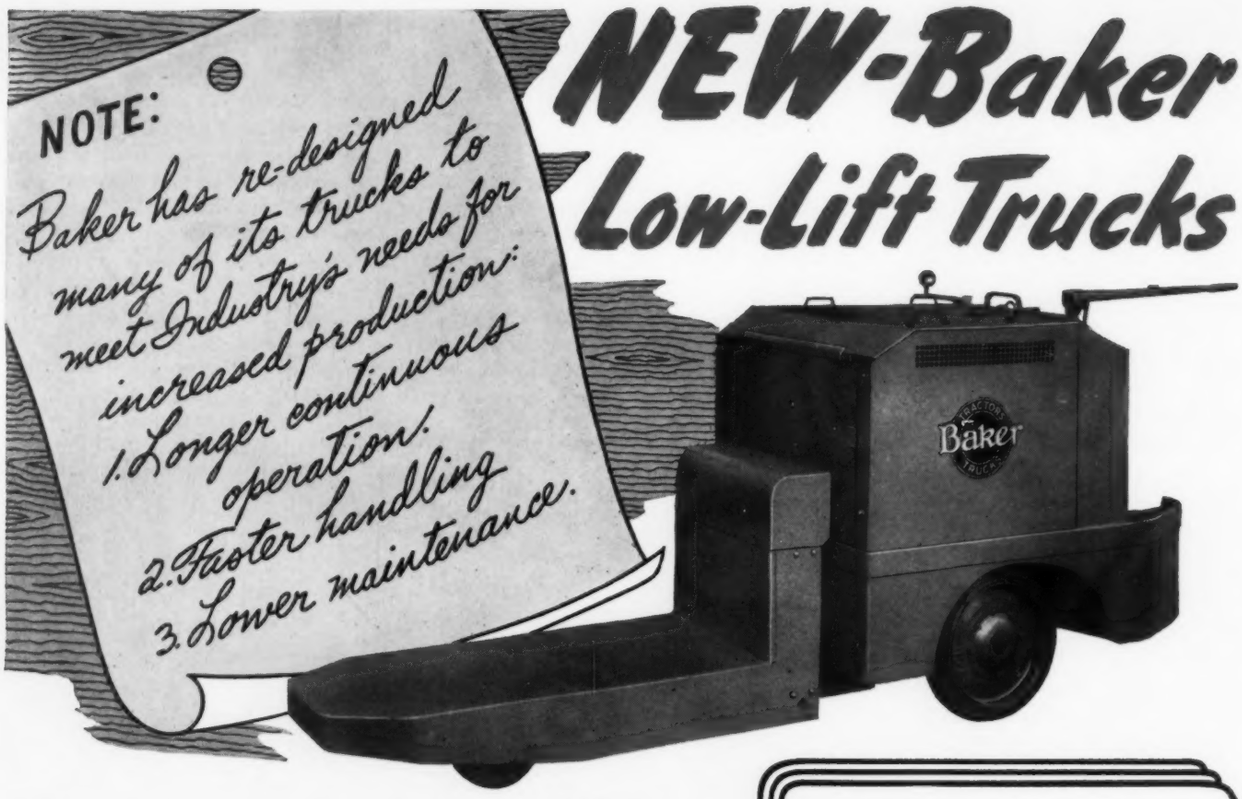
BETTER PRODUCT CONTROL is possible with Hays Draft or Pressure Recorders which are a positive guide to balanced draft conditions in soaking pits, open hearths, slab mills, annealing and other furnaces. They eliminate guesswork, save man power and reduce rejects to the minimum. They are a real help in the all-out effort for bigger and better steel production.

The ten-inch, 24 hour charts give a permanent record of day in and day out performance of every furnace. Two draft values, two pressure values, two differential values or any combination of two of these three values may be recorded. Or temperature may be included if desired and mercury switches may be provided to operate an alarm or a power unit to open and close a damper, etc.

Any way you look at it, the Hays Series OT Draft Recorder is a Guard over furnace operation and merits your investigation. ***Write for Bulletin 39-232.***

The HAYS CORPORATION
SINCE 1901
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

NEW-Baker Low-Lift Trucks


NOTE:
Baker has re-designed many of its trucks to meet Industry's needs for increased production:
1. Longer continuous operation.
2. Faster handling
3. Lower maintenance.
Baker

For Increased Production and Efficiency

● Another forward step in providing faster, safer, and better movement of material has been made by Baker Trucks. This new Low-Lift model, designated as Type E-3, is of 6,000 lb. capacity. The improvements consist of hydraulic lift, increased battery capacity permitting longer continuous operation, chamfered front top corner of battery compartment improving driver's visibility, operator's guard integral with frame for greater strength and safety, and other features which provide increased efficiency and easier maintenance . . . The new improved design is also available in 4,000 lb. capacity (Type E-2).

Write for complete information.

THE BAKER INDUSTRIAL TRUCK DIVISION
of the Baker-Raulang Company
2166 West 25th Street • Cleveland, Ohio
In Canada: Railway and Power Engineering Corporation, Ltd.

NEW Baker Low-Lift Truck
has these advantages:

1. Hydraulic lift system, proved by experience in other Baker Trucks, providing positive control of hoisting and lowering.
2. Larger battery box (32″ x 39½″) permitting enough additional battery capacity so that trucks can be operated continuously for longer shifts.
3. Streamlined design of battery compartment providing greater visibility for operator.
4. Sliding type battery cover equipped with handles for faster servicing.
5. Operator's guard built integral with frame for greater strength and safety and improved appearance.
6. Handy compartment for carrying towing chain, pinch bar, or other tools.
7. Controls in a conveniently accessible panel providing easy maintenance.
8. Alloy-steel trailing axle firmly anchored to frame, wheels steering on anti-friction bearings. Box-section frame to withstand strains and minimize maintenance.
9. Single hex nut for adjusting travel brake located where it can be easily reached.
10. Standard Baker-built travel motor, and exclusive Baker Duplex-Compensating Suspension for smoother running and longer life.

1115-1-43

Baker INDUSTRIAL TRUCKS

ANNOUNCES NEW A-C OUTDOOR WELDER

▲ A new 500-ampere outdoor alternating-current welder has been announced by the General Electric Company. The new welder, which has a welding current range from 100 to 625 amp at 40 volts, is especially designed for use in shipyards and other outdoor locations where exposure to the weather is encountered.

A desirable feature of this welder is an "idlematic" control which automatically reduces the output voltage to less than 35 volts whenever the arc is not in operation, but provides full power for welding the instant the arc is struck. This control also includes a switch operated by a handle extending through the top of the case for starting or stopping the welder manually.

The welder is protected against the entrance of rain, snow and sleet by drip-proof construction of all openings in the top of the case and by a sealed window over the current indicator. Wide louvers serve not only to shed water but to keep air velocity low. All internal parts have a special finish for protection against corrosion from moist air.

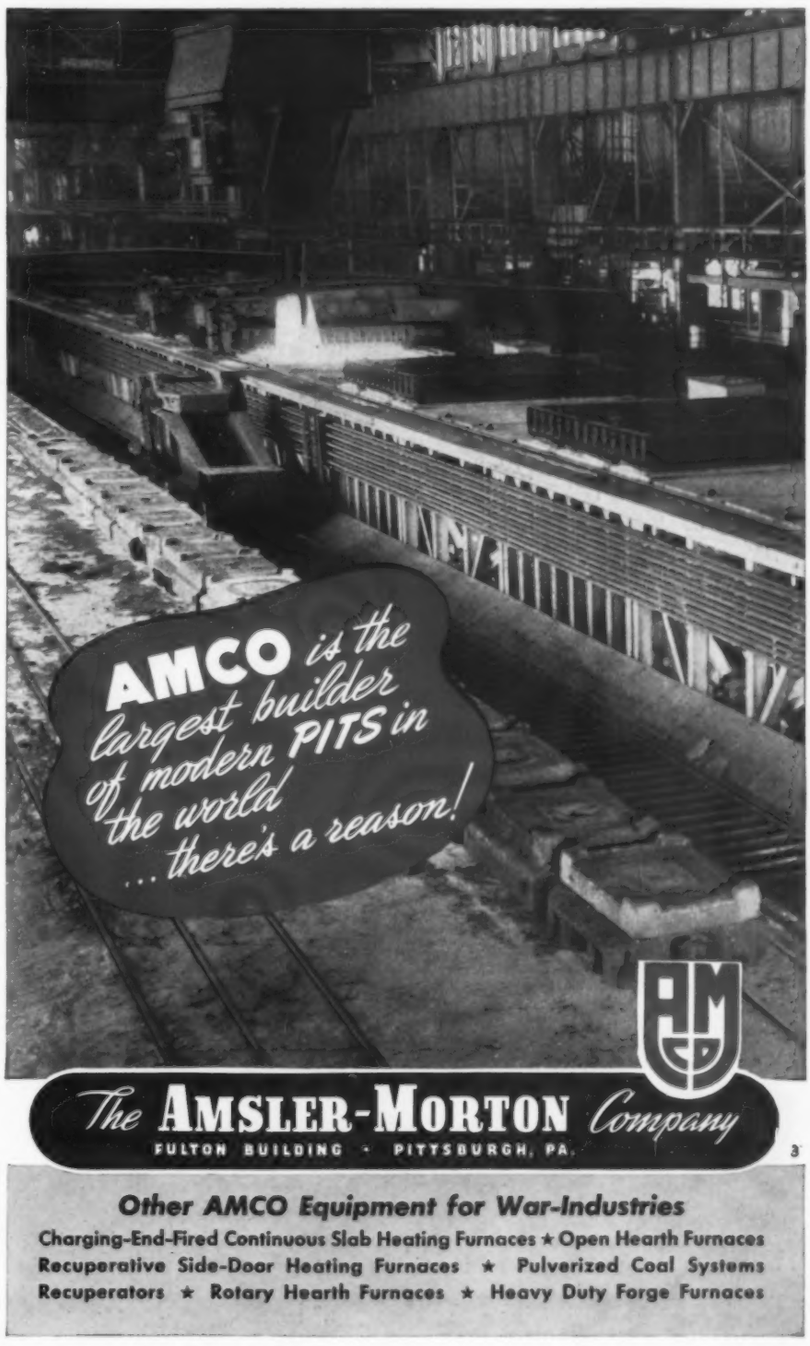
In addition, the welder is provided with all the desirable features incorporated in General Electric indoor a-c welders of this type. These include built-in power-factor improvement which provides low current input by maintaining the power factor at 95 per cent or better at all loads between 40 and 70 per cent of rating. They also include finger-tip adjustment, stepless current control, fan-forced ventilation, and capacity for operation with long leads.

ELECTRONIC CONTROL FOR ELECTRIC FURNACE

▲ Because resistance furnace temperatures are apt to vary, Westinghouse engineers have developed the Furnatron control system to keep such variations to a minimum. This is accomplished through combining a suitable thermo-couple type of temperature controller with automatic electronic control of the saturation current of a saturable reactor connected in the supply line of the furnace elements, thus automatically controlling the power input into the furnace.

The new Furnatron system may be used for furnace temperature regulation and control of a single or three phase furnace. Where the line or furnace transformer voltage is not suitable to supply a-c to the thyratron tubes, an anode transformer is furnished. The droop corrector, another optional feature, is included for installations where the rate of material flowing through the furnace changes, thus compensating for heat exchange due to fluctuations in the rate at which the furnace is being loaded. The Furnatron also included a compensator for line voltage variations, since in some cases the power dissipated is roughly proportional to the third power of line voltage, and variations in such voltage greatly effect the operation of a furnace. The compensator practically eliminates the effect of fluctuating line voltage which is especially important on high thermal inertia furnaces. The complete regulator is arranged for flush panel mounting.

The Furnatron installation is guard-


AMCO is the largest builder of modern PITS in the world ... there's a reason!
AMCO
The AMSLER-MORTON Company
FULTON BUILDING · PITTSBURGH, PA.
Other AMCO Equipment for War-Industries
Charging-End-Fired Continuous Slab Heating Furnaces ★ Open Hearth Furnaces
Recuperative Side-Door Heating Furnaces ★ Pulverized Coal Systems
Recuperators ★ Rotary Hearth Furnaces ★ Heavy Duty Forge Furnaces

TRAINING FOR POSTWAR STEEL EXPORT TRADE

From the four corners of the earth a group of men have gathered for a training program to prepare them for postwar handling of steel products abroad. The training course was organized by the United States Steel Export Company and is designed to familiarize these men with U. S. Steel plants and products as well as all phases of export procedure.

Five of the class are here being shown by plant foremen how axles are burnished at Carnegie-Illinois Steel Corporation's Homestead Works, Wheel and Axle Division, McKees Rocks, Pennsylvania. In the photograph, left to right, are: P. M. Reis and W. S. Saenger of Brazil, Frank Allison, lathe shop foreman, S. G. Tsamis of Egypt, J. R. Bert of New York, W. J. Aranda of Chile, and Harry Klinger, general foreman of the plant's inspection and shipping department.

ed by protective devices which include a time delay relay, over-temperature mechanisms, surge suppressors, fuses and suitable disconnecting devices.

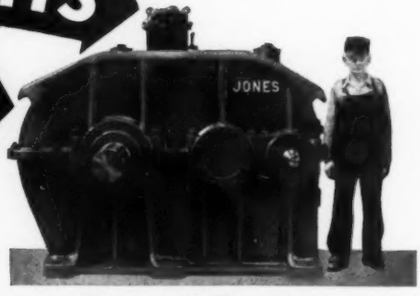
Additional information on the new Furnatron may be secured from department 2-E-54, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

▲ One phase of the Steel for Victory Drive — the share the steel campaign — has already resulted in a gain of more than 1,000,000 tons of steel for use during the last half of this year, it was announced recently by Donald M. Nelson, chairman of the War Production Board.

This figure represents half of the drive's over-all quota of 2,000,000 tons of additional steel for the third and fourth quarters. The other parts of the drive — increased efforts to make more steel from existing facilities, and the acceleration of the completion of selected new facilities — are being pushed, and there is every expectation that the drive will be a complete success.

"The good results of the share the steel campaign are a tribute to the co-operative efforts of steel consumers with the War Production Board and the claimant agencies," Mr. Nelson

Whether you need THIS —or THIS



You can get what you want in the complete range of Jones Herringbone Speed Reducers

YOU will find this 128-page catalog of Jones Herringbone Speed Reducers helpful in the selection of reducers in accordance with A.G.M.A. recommended practice for all conditions of service. Jones Herringbone Speed Reducers are built in single, double and triple reduction types and in every standard ratio in ratings ranging from 1.25 H.P. to 440 H.P.

All these reducers have heat treated gears, ground shafts and are mounted with anti-friction bearings throughout. Liberal stocks are carried to facilitate shipments.

Catalog No. 70 will save you time and effort in laying out drives that call for Herringbone gears.

WRITE FOR YOUR FREE COPY

W. A. JONES FOUNDRY & MACHINE CO., 4431 Roosevelt Rd., Chicago, Ill.

Jones

HERRINGBONE—WORM—SPUR—GEAR SPEED REDUCERS • PULLEYS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES

said. "The allotments which were cancelled or deferred will enable many important programs which otherwise would have been delayed to go ahead to completion.

"Our efforts to secure greater production must not and will not be relaxed. Fourth quarter steel requirements are still some 4,000,000 tons greater than supply. But the success of the share the steel campaign, is encouraging to us all."

The share the steel phase of the campaign was handled by special representatives of the steel division, who visited thousands of plants throughout the country to see if existing inventories permitted cancellation or deferment of orders on steel producers' books. The steel division men were aided by the 13 WPB regional offices.

New Literature

▲ The Trumbull Electric Manufacturing Company of Plainville, Connecticut, has just issued a circular describing and illustrating their line of control centers, including motor control centers and switchboard control centers.

This literature brings up-to-date information on these control centers, which consist of vertical sections containing bus bars, into which are plugged combination control units of magnetic starters and disconnects, sizes 1, 2, 3, and 4, and switch and circuit breaker control units 30 to 600 ampere.

All these units are standardized and prefabricated — saving engineering time in layouts, conserving space, and reducing installation and operating costs.

A copy of this bulletin gladly sent on request.

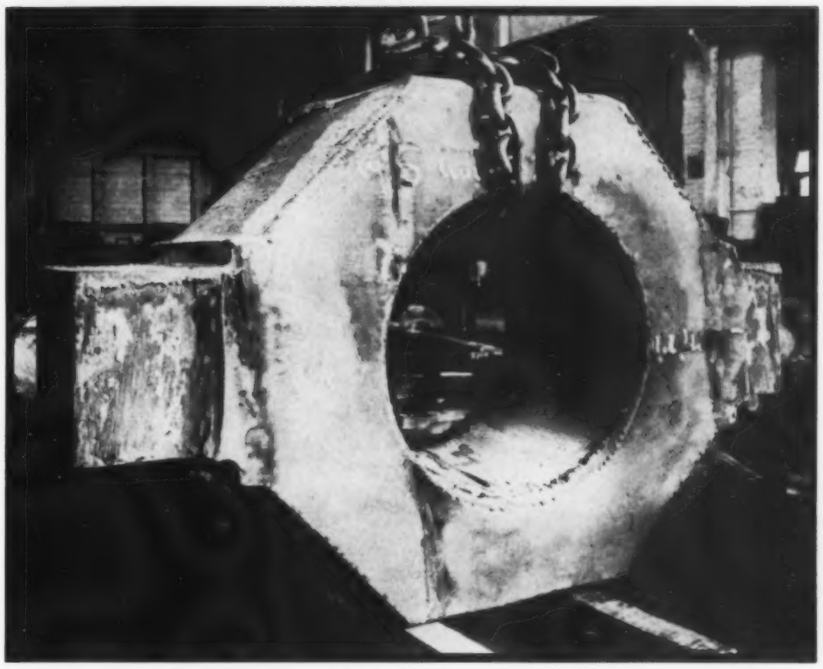
▲ A 37-page booklet bound in simulated leather and priced at $1.50, has been published by the North American Manufacturing Company, Cleveland, Ohio, with the title "Fuel Oil and Its Combustion." Prepared by the research department of the company, the material is presented in concise form under the headings: Crude Oil Constituents and Classification, Crude Oil Processing, Properties of Fuel Oils and Fuel Oil Combustion. An appendix gives methods of calculation for air requirements, ultimate CO_2 and heating values in the combustion of oil.

▲ The fundamental principles of the six basic ways in which electronic tubes function are explained in a new 36-page booklet announced by Westinghouse Electric and Manufacturing Company.

Schematic drawings of the tube construction and diagrams showing the typical circuits for the various functions are used to explain how electronic tubes rectify, amplify, generate, control, transform light into current and current into light. Industrial and military applications for each of the six basic functions are described and illustrated in this booklet, "The ABC of Electronics at Work." High frequency heating, dynetric balancing, resistance welding control, radio and radio-telephony, television, Precipitron, industrial and medical x-ray are a few of the electronic devices that are included.

A copy of booklet B-3260 may be secured from Department 7 N 20.

CROSSHEAD CUT FROM SEVEN-TON SLAB



Skillful applications of the oxyacetylene flame for heavy cutting are hardly out of the ordinary, but the cutting of the mammoth crosshead shown in the photo constitutes a major achievement in that it was shaped by a small gas-cutting machine, even smaller in scope than the size of the work piece. This job was done by a Montreal structural steel plant, employing an Airco Planograph whose normal cutting range is 24 by 72 inches. The crosshead measures 42 by 65 inches, and is 20 inches thick. The seven-ton slab had to be cut in "installments." It was re-positioned several times during the cutting operation to bring first one end, then the other, and the central portion, into the motion range of the cutting torch. The slab was preheated to 400 F, and cutting was done with a water cooled torch with a size No. 15 tip at 40 pounds oxygen pressure. Cutting speed was three inches per minute, all cuts being made on the 20-inch thickness.

Total time for setting up and cutting was only three hours, eliminating at least two weeks' rough machining operations. The quality of cut was remarkable. The crosshead was then annealed and after finish machining it was shipped to its destination via special train. The photo shows the flame-cut crosshead after annealing, before removal of furnace scale.

RECENT GRADUATES IN METALLURGICAL ENGINEERING CHEMISTRY ELECTRICAL ENGINEERING

Men will be employed in Metallurgical laboratories and assigned to work in their respective fields. Electrical Engineers will be thoroughly trained in Metallurgy and assigned to metallurgical problems necessitating a thorough knowledge of the fundamentals of electricity.

Location: vicinity of New York City. In reply, give full particulars: age, education, previous experience. Box No. 99, Iron and Steel Engineer, 1010 Empire Bldg., Pittsburgh, Pa.

Persons in war work or essential activity not considered without statement of availability.

Pneumatic Transmission Recording Flow Controller

PROMPT DELIVERY SCHEDULES

ON FLOW METERS AND FLOW CONTROLLERS

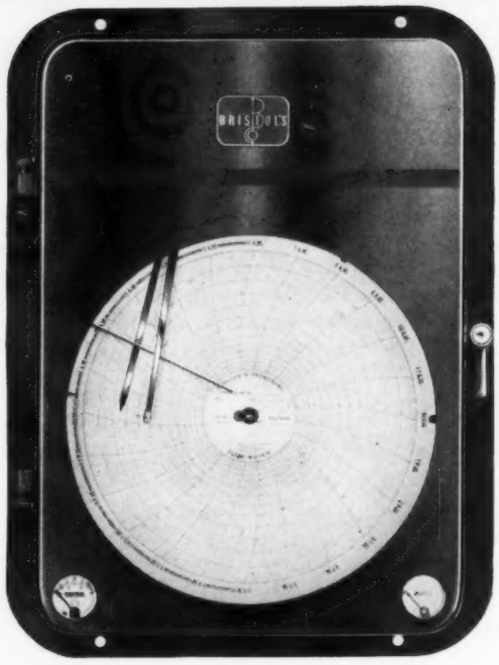
For High Octane Gasoline, Synthetic Rubber and Chemical Programs

The Bristol Company, after making a careful study of probable requirements for flow meters and controllers, has expanded its manufacturing facilities and has set up a planned production schedule which will greatly facilitate delivery.

Models now being produced on a new delivery schedule, include recording flow meters, recording flow controllers and pneumatic transmission flow meters — both recorders and controllers. You can now be more certain of getting these models *in time* to break that meter-bottleneck in your plant!

These models are briefly described in Bulletin F 1601, a data sheet for your files. Write us for complete information.

Bristol instrument application engineers are available, without obligation, to assist in planning proposed installations. This service is particularly helpful during the war period because correct planning and accurate specifications save delivery and installation time and make for successful operation.



Mechanical Recording Flow Controller

THE BRISTOL COMPANY, WATERBURY, CONNECTICUT

The Bristol Co. of Canada, Ltd.
Toronto, Ontario

Bristol's Instrument Co., Ltd.
London N. W. 10, England

... Gives YOU the Most from Heat

AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

FLOW METERS — QUICK DELIVERY COUPON

THE BRISTOL COMPANY
123 Bristol Road, Waterbury, Conn.

Please send me information about Bristol Recording Flow Meters and Flow Controllers on improved delivery schedule plan.

NAME.....

COMPANY.....

ADDRESS.....

.....

A DROP OF PROTECTION

This little drop with billions of others, taken collectively, form the impervious film which protects the giant transformers, generators and motors of American industry as well as the special electrical units required by our Armed Forces. Such is insulating varnish although only a few mils thick, it provides the necessary protection to electrical units.

Perhaps you do not know just what type of varnish to specify for treatment of your newly designed units. It is a very complex problem for varnish insulation and treatment which may prove very successful for one type of an electrical unit may be entirely unsatisfactory for another.

We maintain a fully equipped laboratory for those who are confronted with an insulating varnish problem. We are confident, no matter what your problem may be, that with our years of research and specialization in the field of insulating varnishes, we can help you. There are no obligations, so why not let us assist you?

MANUFACTURERS OF

CHINALAK Insulating Varnishes
SYNTHITE Insulating Varnishes
Stator Compounds
Filling Compounds
Cable Enamels
Radio Waxes
Melting Compounds
Sticking Compounds
Red Oilproof Enamels

Dolph's

JOHN C. DOLPH COMPANY

Insulating Varnish Specialists

166A EMMETT ST. NEWARK, N. J.

NATIONAL ROLLS

The Keys To Profit and Prestige

ROLLS are the key-implements of the rolling mill; and upon them largely depend the profit of the mill and the good will of its customers.

Rolls of reliable endurance performance develop greater net profit by lowering costs.

And rolls that also turn out a superior product create the assets of good will and prestige — as desirable as profit itself.

Each NATIONAL ROLL is formulated and processed to deliver reasonable range of output of a quality that will reflect credit on the issuing mill.

And in all normal situations, we consider the quality of output as important as tonnage excess.

The NATIONAL
ROLL & FOUNDRY CO.
All Grades of Plain and Iron Alloy Rolls - Both Chill and Grain Types
Heavy Iron Castings and Rolling Mill Equipment
AVONMORE, PA.

OHIO
Maximum Lift MAGNETS

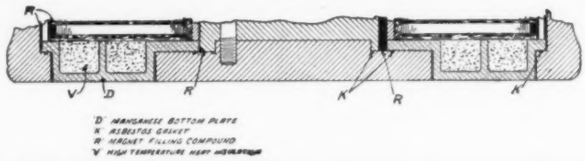
The OHIO six pancake coil magnets in the 55" and 65" diameters will average 35% better lifts than the standard magnets.

The OHIO eight pancake coil magnets will lift 75% more than the standard magnets.

Labor cost per ton and time required to handle are both reduced correspondingly.

Numerous repeat orders testify that performance equals or exceeds the statements above.

When OHIO magnets are required to lift hot materials the heat resisting bottom construction shown below successfully prevents the heat of the load from increasing the temperature of the magnet coil and permits all day use.

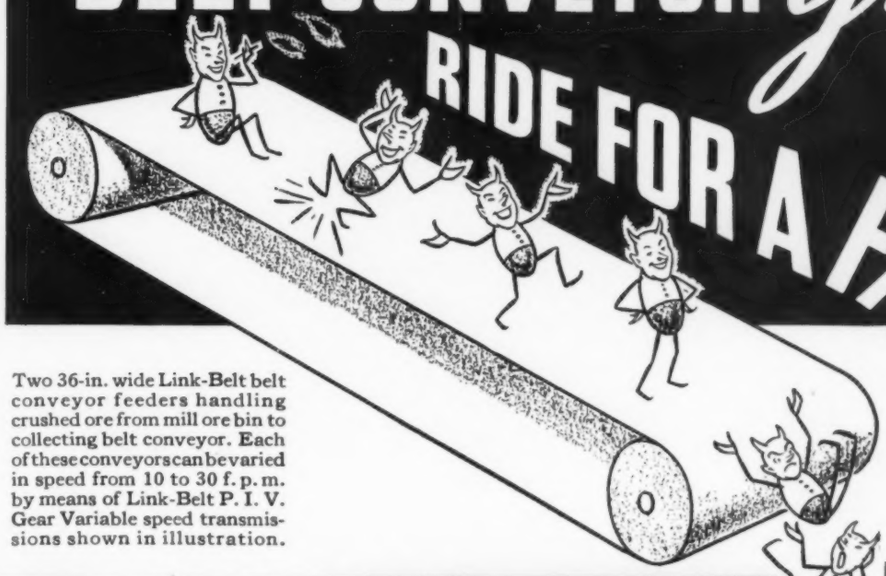


Such magnets can handle hot material all day.

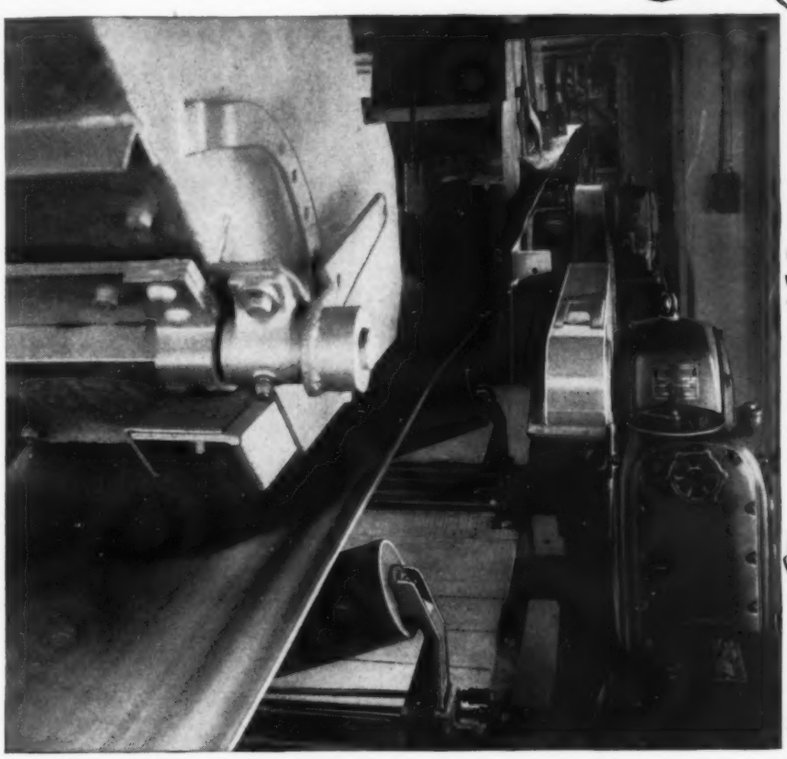
Have you a problem requiring fast lifting or lifting of hot steel?

The OHIO Electric Mfg. Co.
5907 Maurice Avenue Cleveland 4, Ohio

BELT CONVEYOR *Gremlins* RIDE FOR A FALL



Two 36-in. wide Link-Belt belt conveyor feeders handling crushed ore from mill ore bin to collecting belt conveyor. Each of these conveyors can be varied in speed from 10 to 30 f. p. m. by means of Link-Belt P. I. V. Gear Variable speed transmissions shown in illustration.



WHEN YOU DO THESE SIX THINGS:

1. KEEP INSTALLATION CLEAN

Make periodic inspections daily to see that there is no accumulation of material that has spilled off the belt.

2. USE IMPACT IDLERS . . .

Rubber-tread impact idlers at loading and transfer points will prolong belt life by preventing cutting and bruising.

3. "TRAIN" THE BELT . . .

For efficient operation, keep both the carrying and return runs of a conveyor belt practically centered on the supporting idlers.

4. MAINTAIN THE "TRAINING"

Maintaining the "training" of the belt on the conveyor is assured at all times if self-aligning idlers are used.

5. MAINTAIN BELT TENSION

Proper belt tension eliminates excessive belt sag between idler rolls and prevents unnecessary wear.

6. LUBRICATE PROPERLY . . .

Never over-lubricate idler rolls and other moving parts, for too much lubrication is as bad as too little.

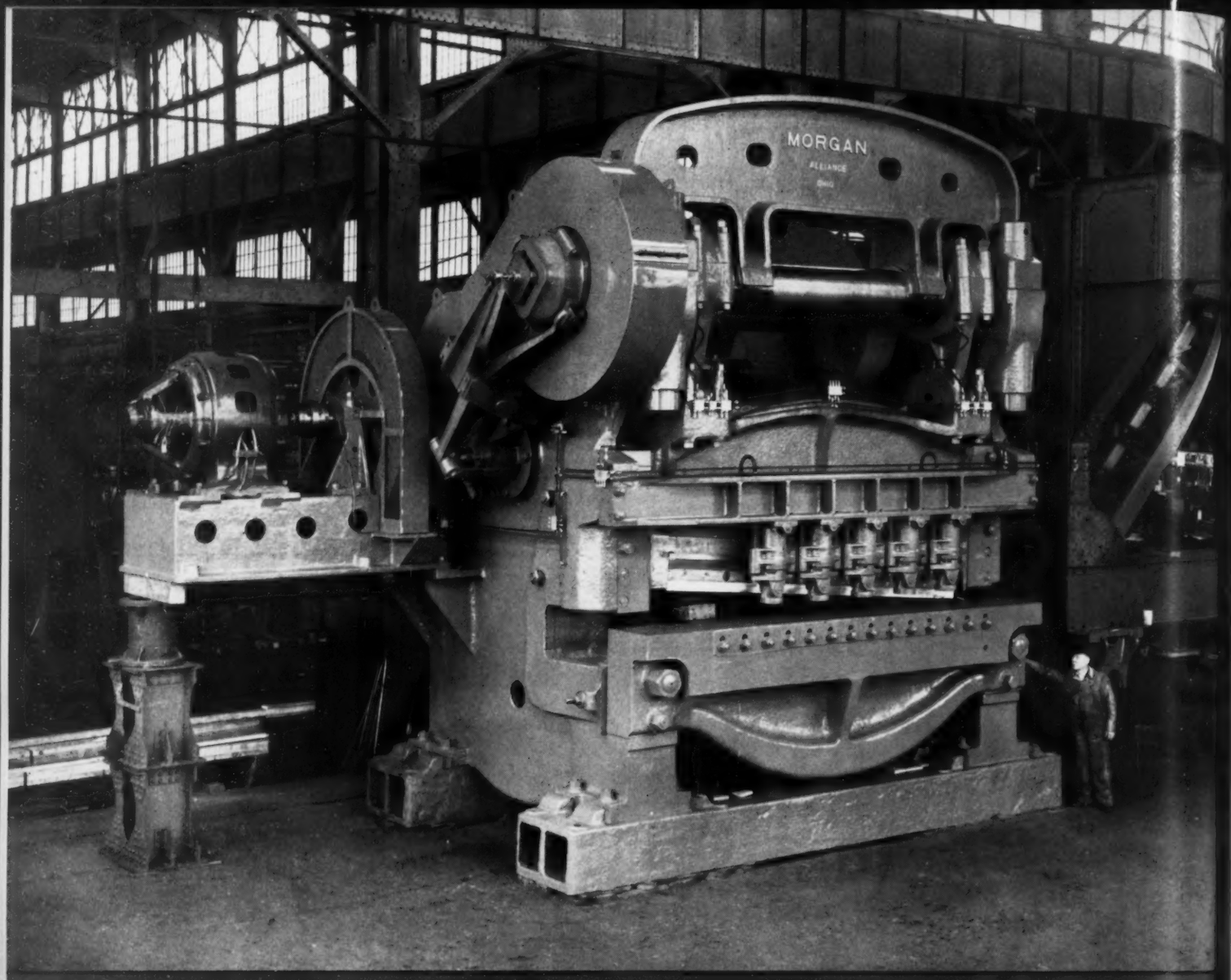
GREMLIN CHASERS: Inspect equipment regularly—and make replacements with genuine Link-Belt parts when necessary. Link-Belt manufactures a complete line of idlers, pulleys, bearings, take-ups, drives, trippers, etc., for every service.

LINK-BELT
BELT CONVEYOR EQUIPMENT

LINK-BELT COMPANY

Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Dallas 1, San Francisco 24, New York 7, Toronto 8, Cleveland 13, Pittsburgh 19, Detroit 4, Offices, warehouses and distributers in principal cities.

S201C



BUILT BY MORGAN *Engineering*

FOR SHEARING 2″ ARMOR PLATE

● Among the many types of mill equipment built by Morgan, is the 144″ plate shear illustrated above for shearing 2″ armor plate. Push button control is provided for operating the hydraulic clutch and hydraulic hold-downs. Of massive construction, this shear is typical of the type of mill equipment Morgan designs and builds. Morgan engineers rely upon a highly skilled shop organization, modern equipment and progressive ideas in building steel mill machinery.

DESIGNERS • MANUFACTURERS • CONTRACTORS
Blooming Mills • Plate Mills • Structural Mills
Electric Traveling Cranes • Charging Machines
Ingot Stripping Machines • Soaking Pit Cranes
Electric Welded Fabrication • Ladle Cranes
Steam Hammers • Steam Hydraulic Forging
Presses • Special Machinery for Steel Mills

THE MORGAN ENGINEERING CO.
ALLIANCE, OHIO

Pittsburgh, 1420 Oliver Building

ITEMS OF INTEREST

D. H. Barr has been appointed as assistant to the general superintendent of the Johnstown-Lorain Works, Carnegie-Illinois Steel Corporation. In his new position, Mr. Barr will be responsible for the development and installation of methods, procedures, and production planning at this U. S. Steel subsidiary plant.

After his graduation as mechanical engineer from Carnegie Institute of Technology in 1929, Mr. Barr went with the Bell Telephone Company in New York City where he spent nine years as industrial engineer. He left this position to go with his father in an independent gold and silver mining enterprise in the western states. He joined Carnegie-Illinois in July, 1940, and before his present appointment was assistant to the Pittsburgh district industrial engineer.

WILLIAM HAGEL

G. G. Beard has been made vice-president in charge of sales engineering, United Engineering and Foundry Company, Pittsburgh, Pennsylvania. Following his graduation from Royal Technical College in mechanical engineering and post graduate work at Royal School of Mines, Mr. Beard worked as research engineer in the Bureau of Mines, London, England. He joined United in 1927 as a draftsman and was subsequently transferred to sales engineer.

William Hagel has been named manager of machinery sales, succeeding **John L. Young,** who was made manager of industrial research for United. Mr. Hagel first joined United in 1917, and graduated from Carnegie Institute of Technology night school in mechanical engineering. He has successively held the positions of estimator, chief estimator, and assistant to sales manager before his new appointment. Mr. Young came to United from Timken Roller Bearing Company in 1935, and held the position of manager of machinery sales until the present change.

F. W. Waterman, Jr., has been appointed forecast engineer of the Carnegie-Illinois Steel Corporation. His new position places him in charge of the forecast bureau, which develops and recommends plant additions and improvements of this U. S. Steel subsidiary, based on market and financial studies.

Mr. Waterman began his engineering career in 1923 with the National Tube Company at Gary, Indiana, where he became superintendent of the skelp mill. After six years with National Tube, he served successively as chief engineer of the National Radiator Company and the Century Stove Company, both of Johnstown, Pennsylvania. In 1937 he was named president of the Dustin Company in the same city, holding that office until

G. G. BEARD

1940, when he entered the forecast bureau of Carnegie-Illinois as market and equipment engineer.

Born in Sydney, Nova Scotia, Mr. Waterman was graduated from Phillips Exeter Academy and received his engineering training at Cornell University and Massachusetts Institute of Technology.

James J. Nelson has been appointed as general manager of the Cramp Brass and Iron Foundries division of The Baldwin Locomotive Works.

Mr. Nelson joined the Cramp Brass and Iron Foundries Company in 1932 as vice president and sales manager, and when the company became affiliated with the Baldwin group, he continued as sales manager of the Cramp division.

Previously Mr. Nelson was associated with the American Manganese Bronze Company as New York representative, and in 1926 he moved to Philadelphia to become sales manager of that company.

Mr. Nelson served in the United States Navy from 1912 to 1919, resigning as a lieutenant to become assistant on the Joint Board of Review, which arranged for the return to private owners of hundreds of vessels commandeered by the government during the first world war.

SWINDELL HIGH TEMPERATURE CAR-TYPE FURNACES

LET US CONSULT ON YOUR PRESENT FURNACE PROBLEMS

SWINDELL-DRESSLER Corporation
DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES
PITTSBURGH, PA.

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Can you get

each of your employes to

BUY AN EXTRA $100 BOND

in September?

That's the problem.

That's the job of the Third War Loan.

The objective is to raise fifteen billion dollars. No one ever set out to raise fifteen billion dollars at one time before in all the history of the world. To raise that kind of money, you have to go where the money is . . . the idle money.

72% of all the *idle* money is estimated to be in the hands of people who work for wages.

They are the employes on your *payroll* and the employes on other business men's *payrolls*.

You are the quickest, most direct route to those millions of men and women.

You know them.

You have access to them.

They are *your* particular *prospects*.

If you can get each of them to buy at least one extra $100 war bond (price: $75), in addition to their regular payroll deduction purchases, the Third War Loan will be a success.

We are listing below some of the things you can do to help sell an extra bond to each one.

Will you do them?

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

HERE'S HOW TO DO IT!

This brief outline was prepared expressly for your use by a nationally-known firm which recently directed a successful war bond selling drive among a large group of Koppers employes.

You have undoubtedly served on some money-raising campaign in your city . . . for your favorite hospital, or community fund, or Red Cross.

You know how those campaigns are organized.

Organize one in your own plant or plants for the Third War Loan.

1. Appoint a campaign committee, or have the labor-management committee appoint one.

2. Head it up with a chairman who is aggressive and a go-getter.

3. Have committees set up for each shop or each department. Organize them as teams, to compete with each other. Americans love competition . . . we love to make a game of our work. Appoint leaders for all committees and give them military titles.

4. Appoint a campaign manager who can devote full time to the campaign until you reach your goal.

5. Start with a big rally. Get your local Army or Navy office to send officers and men to take part in the rally, or have a returned war hero appear, for morale purposes. If you are working on war work make some special shipment as part of that rally.

6. Put up exhibits and posters around the plant which you can get from your local War Loan headquarters.

7. Have a bulletin board on which you can post daily the *percentage* of employes who have signed up in each department or on each team.

8. Have some newspaper publicity about what you are doing. It will encourage your people and will help the company, too. Tell the publicity director of your local War Bond campaign what you are doing.

9. Where employes are unable to afford a $75 expenditure for a $100 war bond, encourage them and members of their families to sell war stamps to their friends and neighbors and credit these sales against the team total.

10. End the campaign with a rally and honors or prizes for the biggest producers or hardest workers.

KOPPERS COMPANY AND AFFILIATES, PITTSBURGH, PA.

KOPPERS

★ ★ ★ ★ ★ **THE INDUSTRY THAT SERVES ALL INDUSTRY** ★ ★ ★ ★ ★

PROTECT YOUR WORKERS —
SPEED YOUR MARKING WITH

HAND HOLDER

Wedge Grip knurled to prevent slipping. One-piece construction, no rivets, no welding. Patented safety snap for changing figures. Made for any size character, any number of pieces. Write to —

M.E. CUNNINGHAM CO.
SAFETY STEEL STAMPS
105 CARSON STREET, PITTSBURGH, 19, PA.

ROWAN
Oil Immersed
MOTOR CONTROL

BY
USERS
EVERYWHERE

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

Upon completion of his duties with the Joint Board of Review, Mr. Nelson became assistant to the chief supervisor in charge of repairs of the Shipping Board. In this capacity he handled the propeller replacement program on some 1,400 vessels for the Shipping Board.

Frederic I. Lackens, advertising manager of the Hays Corporation, Michigan City, Indiana, manufacturers of combustion instruments and control, has been elected president of the National Industrial Advertisers Association, Inc.

FREDERIC I. LACKENS

The N. I. A. A. is the largest body of specialized advertising men in the world, having a membership of over 2200 with 27 chapters located in as many industrial centers in the U. S. A. and Canada.

Mr. Lackens is widely known in advertising and industrial circles, having been connected intimately with both since before the first world war. His new duties as president of N. I. A. A. will not disturb his connection with the Hays Corporation.

J. M. Komp, superintendent of blast furnaces and coke ovens, Republic Steel Corporation, Central Alloy district, Canton, Ohio, moves to the Cleveland district as superintendent of blast furnaces and coke plant.

Mr. Komp was born in Joliet, Illinois. His first eight years in the steel industry were spent in that city, divided almost equally between the by-product coke plants of the Illinois Steel Company and the Coal Products Manufacturing Company. In 1916 he moved to Canton, Ohio, as assistant superintendent of the by-product coke plant of the United Furnace Company. Three years later he was made superintendent of this plant, and in 1927, was appointed superintendent of coke plants at Canton and Massillon for the Central Alloy Steel Corporation, later acquired by Republic Steel Corporation. Since 1933 Mr. Komp has been superintendent of blast furnaces and coke ovens for Republic's Central Alloy district.

Thomas Cosgrove, general foreman of coke plants in the Central Alloy district since 1930, has been appointed superintendent of blast furnaces and coke plants there, succeeding Mr. Komp.

Mr. Cosgrove was born in Braddock, Pennsylvania,

and is a graduate of Cornell University in civil and mechanical engineering. His first employment was with the Carnegie Steel Company in the engineering department of the Duquesne plant. Subsequently he spent two years in the mechanical department of the Edgar Thompson Works of Carnegie, and in 1914 went to the Koppers Company as a construction and operating engineer. Five years later Mr. Cosgrove joined the United Furnace Company in Canton where he remained through subsequent corporate changes to become general foreman of coke plants under Republic Steel Corporation in 1930.

Jones M. Cahill, superintendent of open hearths in Republic's Youngstown district, has moved to Gadsden, Alabama, as superintendent of open hearths for the Gulf Steel Division of Republic's southern district.

Jones M. Cahill was born in Pendleton County, Kentucky, attended public schools in Middletown, Ohio, and following graduation from high school there went to work for the American Rolling Mill Company as an open hearth clerk. Serving successively as stockhouse foreman, labor foreman, second helper and first helper, he was made melter foreman in 1918, remaining on this job until 1930 when he became assistant open hearth superintendent of the Ashland, Kentucky, plant of American Rolling Mill Company. He came to Republic Steel Corporation in 1932 as assistant open hearth superintendent at Youngstown and since 1937 has been superintendent of open hearths in Youngstown for Republic.

Harvey McKenney has been appointed as manager of alloy steel sales for the Follansbee Steel Corporation.

A native of Pittsburgh, Mr. McKenney has spent virtually all of his business career in the alloy field both in production and procurement. He was associated with the Carnegie-Illinois Steel Corporation and the Crucible Steel Company in the production phase of the business.

When the British Iron and Steel Corporation, Ltd., was formed in the United States, Mr. McKenney became its progress advisor. Later he served in a similar capacity with Raw Materials Mission II. More recently he was associated with the War Production Board in the alloy section, iron and steel branch.

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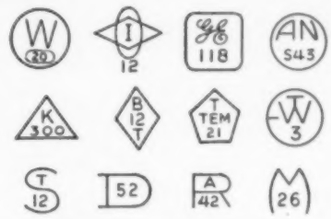

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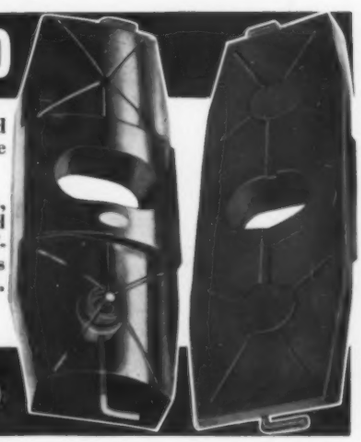

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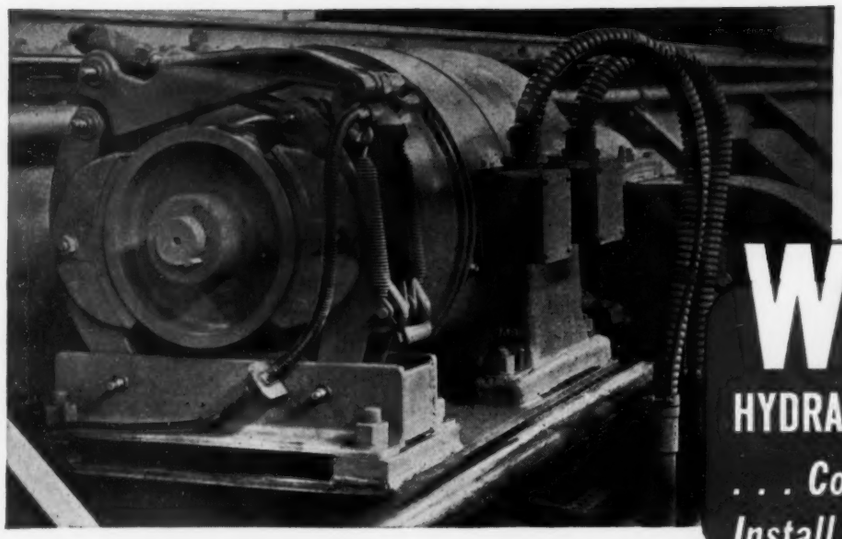

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Brake Assembly – Type H illustrated is for inside cranes. Type HM for outside cranes.

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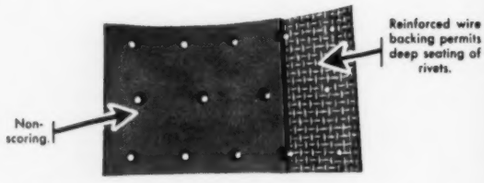

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Users of Wagner hydraulic braking systems, as well as every maintenance man responsible for the safe and efficient operation of overhead cranes, should have this bulletin on brake installation and service instructions. This new bulletin gives full installation and maintenance information and will be sent upon request. Write today for bulletins IU-18B and IU-20.

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143-4

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Fred E. Harrell, assistant chief engineer of the Reliance Electric and Engineering Company since 1934, has been appointed chief engineer of the company, reporting to A. M. MacCutcheon, engineering vice president.

For the past ten months Mr. Harrell has been acting as executive director of a new marine division plant for Reliance. This special assignment has been carried out

FRED E. HARRELL

with such marked success that this third Reliance plant is now well into volume production of special-purpose electric motors for the Navy and Merchant Marine.

A native of Logansport, Indiana, Mr. Harrell came to Reliance in 1924 upon graduation in electrical engineering from Purdue University. In 1927 he was transferred from sales engineering in the company's Chicago office to general engineering in Cleveland. Since then he has had charge of the drafting room, of alternating current design work, and since 1934 has been assistant chief engineer.

Robert W. O'Neal has joined the Follansbee Steel Corporation organization at Follansbee, West Virginia, and Toronto, Ohio, as industrial engineer in charge of methods and standards.

Following graduation from the University of Pittsburgh in 1933, he joined the industrial engineering department of Carnegie Steel Company. Later he became assistant plant industrial engineer, Irvin Works, Carnegie-Illinois Steel Corporation, which position he held until coming with Follansbee.

Arthur E. Murton has been appointed manager of the roll department of Continental Roll and Steel Foundry Company. His headquarters will be in the company's offices, 903 Grant Building, Pittsburgh, Pennsylvania.

Philip Schane, Jr., has been appointed chief process metallurgist of the Pittsburgh district metallurgical division of the Carnegie-Illinois Steel Corporation.

A graduate of the Carnegie Institute of Technology, Mr. Schane was first employed by the Carnegie Steel Company at Homestead Works and later held a position in the metallurgical division of the company's Pittsburgh general office. He was appointed chief metallurgist at the Duquesne Works in 1932, and four years

later was transferred to the company's Youngstown, Ohio, Works where he held the same position. He returned to Duquesne as chief metallurgist in 1937, holding that position at the time of his new appointment.

Jack Meyer has been appointed vice-president and general superintendent, and **L. T. Anderson,** vice-president in charge of sales and engineering for the National Alloy Steel Division of the Blaw-Knox Company.

S. R. Kallenbaugh has been appointed west coast district manager of the steel and tube division, Timken Roller Bearing Company, Canton, Ohio, whose western offices are at 1526 South Olive Street, Los Angeles, California.

Mr. Kallenbaugh is a graduate of Mt. Union College, and has had post-graduate training in metallurgy at Ohio State University. Until his recent transferal, he was metallurgical service representative for the Timken Roller Bearing Company in Cleveland and Detroit.

Fred W. Pennington, until recently in the publicity department of the Westinghouse Air Brake Company, has been appointed manager of publications and advertising for Kennametal Inc., at Latrobe, Pennsylvania.

Mr. Pennington's background of experience includes engineering, commercial engineering, technical writing, and the preparation of sales literature and business paper advertising. He is a past president of the Pittsburgh Advertising Club, and now a director of the Pittsburgh chapter of the National Industrial Advertisers Association.

Obituaries

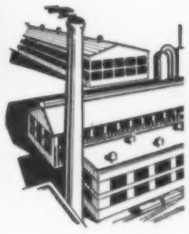
W. F. Clemens, of the engineering department of Great Lakes Steel Corporation, died July 4th at his home in Detroit, Michigan. Born in Chicago, Illinois, and a graduate of Valparaiso University, Mr. Clemens had been connected with Great Lakes since 1929. He was a member of the Association of Iron and Steel Engineers and the American Society of Mechanical Engineers.

Charles E. Malley, sales manager of the Springfield plant of the Ohio Steel Foundry Company, died in his residence at Springfield, Ohio on July 11, following several months' illness.

Mr. Malley had been associated with Ohio Steel Foundry Company since 1924 and was sales manager at Springfield for the last seven years. He was specialist on the engineering, application and sales of the company's heat and corrosion resisting alloy castings. Mr. Malley was a member of the OPA Steel Casting Industry Advisory Committee and of the Alloy Casting Industry, and was active in the affairs of the Alloy Casting Institute and of the Steel Founders' Society of America.

Roy F. Gale, plant engineer, Midvale Company, Philadelphia, Pennsylvania, died July 26th, 1943. A graduate of Massachusetts Institute of Technology, Mr. Gale joined the engineering department of the Midvale Company in 1909 and in 1917 was made electrical engineer. He was made plant engineer in 1920, and in 1940 was placed in charge of the special defense expansion program. Mr. Gale was a member of the Association of Iron and Steel Engineers since 1917, and acted as chairman of the Philadelphia Section in 1918.

Free-Flow Fan Type



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By so doing, you help your nation, you help your workers, and you also help yourself. In plant after plant, the successful working out of a Pay-Roll Savings Plan has given labor and management a common interest and a common goal. Company spirit soars. Minor misunderstandings and disputes head downward, and production swings up.

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Do:

. . . order your wire requirements as far in advance as possible so that manufacture of your material can be planned in our production schedule.

. . . consult with government engineers to check with their requirements before purchasing cable for a *government financed project.*

. . . try, wherever possible, to use designs of cable that are available in stock or the simplest to make.

. . . avoid complicated splices and fittings. Your Okonite representative can tell you how to simplify installations.

. . . supply us with cutting lengths promptly as we cannot start manufacture, in most cases, until we have this information.

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. . . specify cables that are unnecessarily complicated. Each operation on a cable requires special machines, any one of which may be cause of delay. Keep your cable design simple. Consult your Okonite representative as to how you can do this.

. . . order short lengths of many sizes. Standardization on a few sizes almost always results in lower cost per foot and much quicker delivery.

. . . send your order in without specifying conditions of installation, supplying properly certified allotment number or symbol and Army, Navy or other government contract number—if any. This information is necessary before your order can be included in our production schedule.

OKONITE is able to supply many types of electrical wires and cables subject, of course, to War Production Board limitations. If you need insulated electrical conductors, get in touch with your nearest Okonite representative; he can help you in many ways . . . The Okonite Co., Passaic, N. J.

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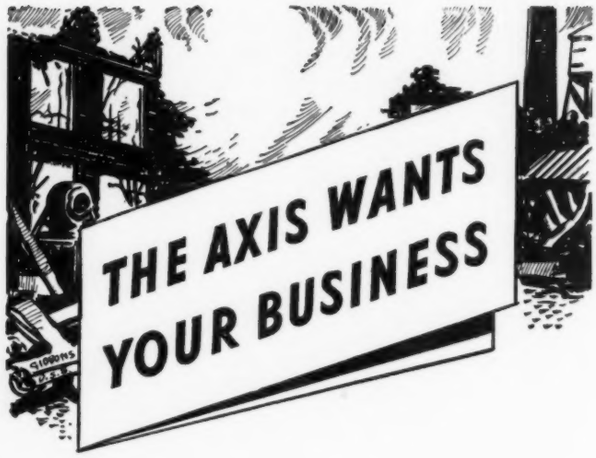

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CONTROL PANELS AND ACCESSORY SWITCHES

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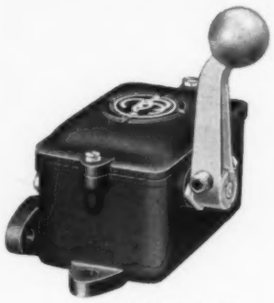
TYPE RD MASTER SWITCH



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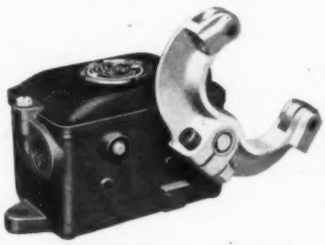
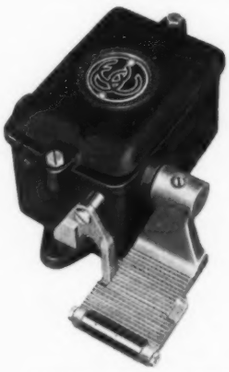


BULLETIN 101 • TYPE TLF
TRACK TYPE LIMIT SWITCH



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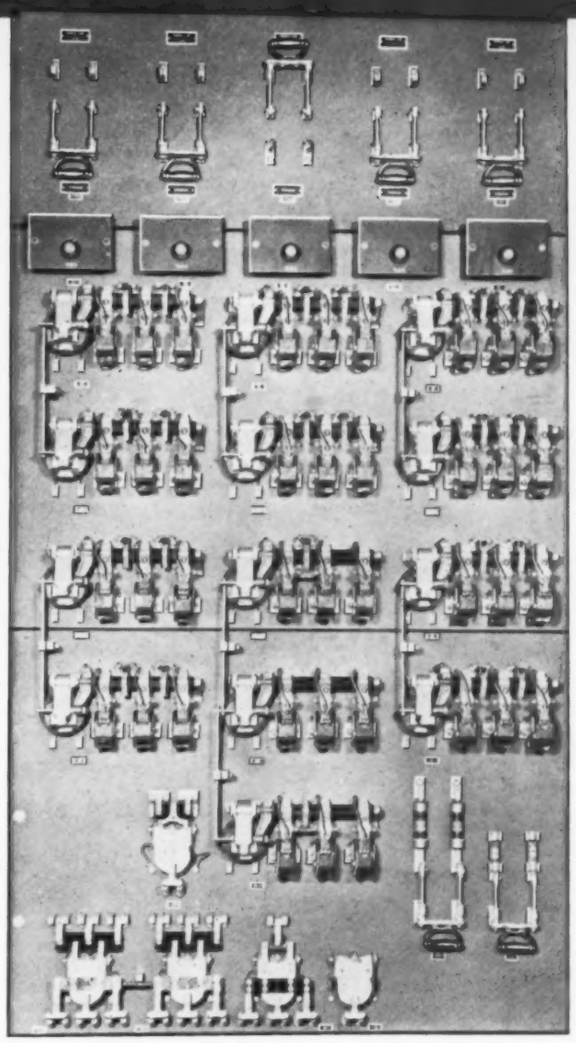

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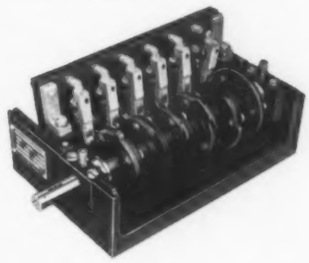

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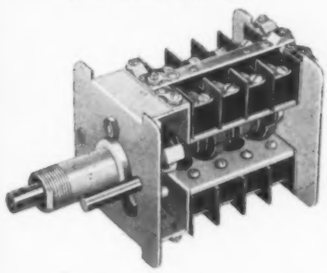

BULLETIN 101
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BULLETIN 102
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THAT'S WHAT NORMA-HOFFMANN FIELD ENGINEERS ARE DOING, TODAY

★ They're out on America's "production fronts," giving freely of their highly specialized experience, assisting manufacturers of armament, equipment, munitions and supplies in keeping production lines moving. They're aiding MACHINE BUILDERS to apply anti-friction bearings more economically and efficiently. They're helping MACHINE USERS to get the most from the bearings they have—to lengthen their life—to reduce shut-down hazards. At our factory, The Engineering and Research Departments are equally busy, solving problems in bearing application, operation and maintenance submitted by buyers of bearings in every field. And all this service is being rendered without cost, THAT AMERICA MAY PRODUCE MORE.

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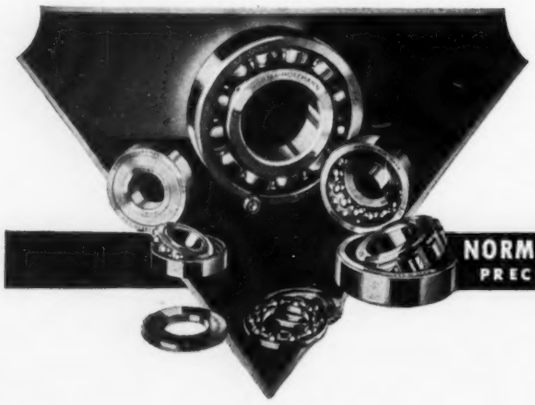
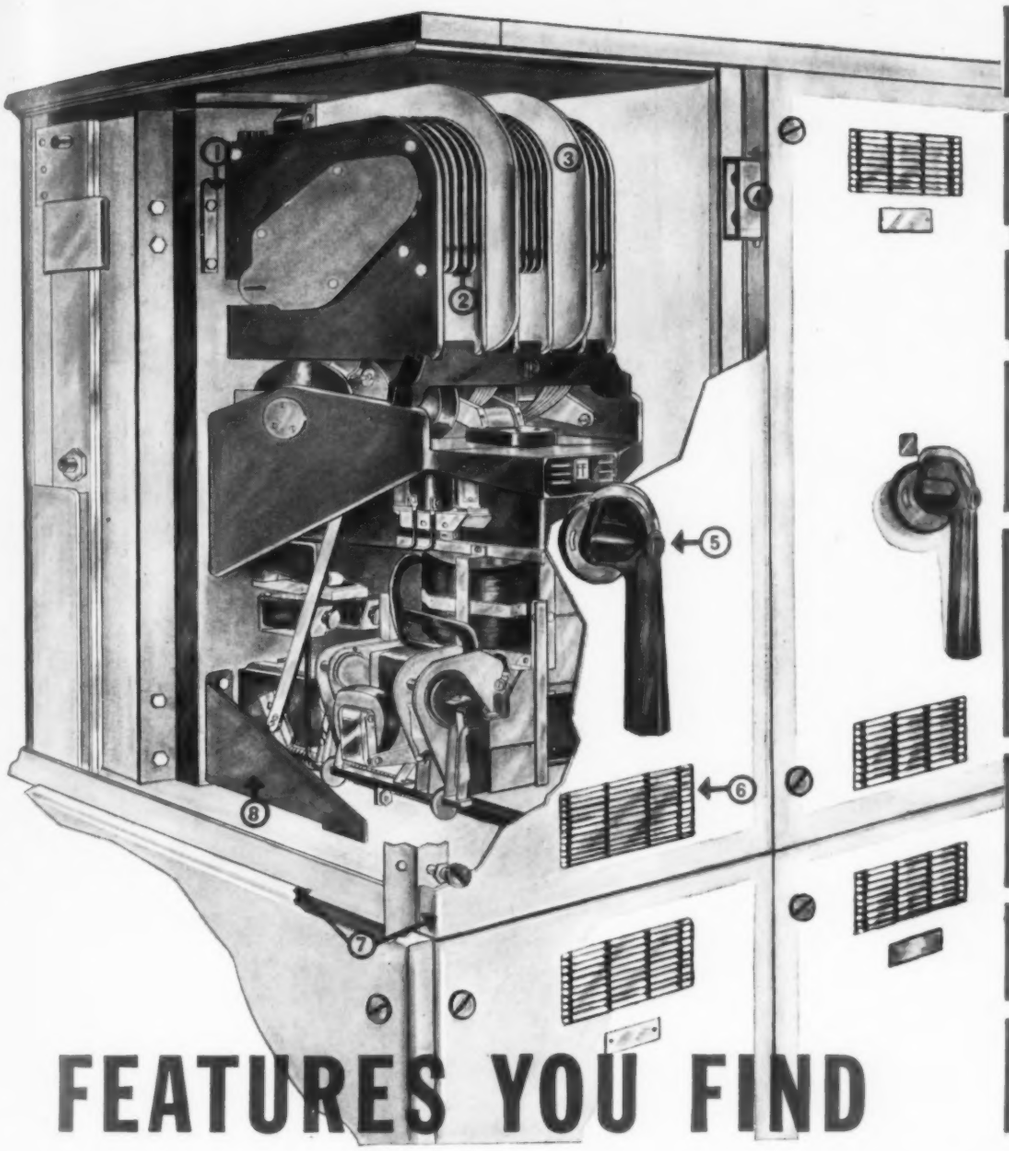


NORMA-HOFFMANN BEARINGS CORP'N., STAMFORD, CONN., U.S.A.
PRECISION BALL AND ROLLER BEARINGS — FOUNDED 1911

BUY MORE UNITED STATES WAR BONDS, TODAY



① **LIFTING HOOK**—for ready removal of the circuit breaker for inspection, using overhead crane or portable hoist.

② **ARC CHUTES**—Magnetic blowout construction provides rapid, safe extinction of arcs from short circuits or heavy overloads.

③ **INSULATING BARRIERS**—provide phase insulation additional to that furnished by arc chutes.

④ **HINGES**—To permit ready drawout of circuit breaker for inspection, hinges allow door to open 100 degrees. They are invisible when door is closed and are slotted to permit individual alignment and adjustment of the door.

⑤ **ROTARY DOOR HANDLE**—attached to hinged door, provides both closing and tripping. Disengages automatically from circuit breaker when door is opened. Thumb-operated locking plate in the top can be raised when handle is in trip position to hold up to three padlocks for protection of workmen against energizing of line before clearance is given.

⑥ **GRILLE-TYPE LOUVERS**—at top and bottom of each door, provide ample air circulation, dissipating heat from series coils. Baffle design helps in keeping out dust.

⑦ **FLANGED DOORS AND PANELS**—make rigid, non-warping members without use of needlessly heavy-gauge sheet.

⑧ **BASE FOOT**—makes the circuit breaker a self-standing unit when removed from compartment and placed on floor or inspection bench.

FEATURES YOU FIND IN I-T-E DRAWOUT SWITCHGEAR

As a method of clearly showing hidden parts, the I-T-E Engineering Department offers this perspective cut-away drawing which has advantages over either photographic or the usual mechanical treatment. We plan a series of these to make the clearest possible explanation of Multumite advantages.

Multumite switchgear assemblies are completely metal-enclosed structures in which I-T-E incorporates many features, including those above, for safety and convenience in control and distribution of electric power.

Write for Bulletin 4207—a thorough description of I-T-E Multumite drawout switchgear.

I-T-E

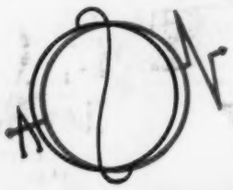
AIR SWITCHGEAR

IMMERSED IN AIR • ENCASED IN STEEL

Representatives in Principal Cities

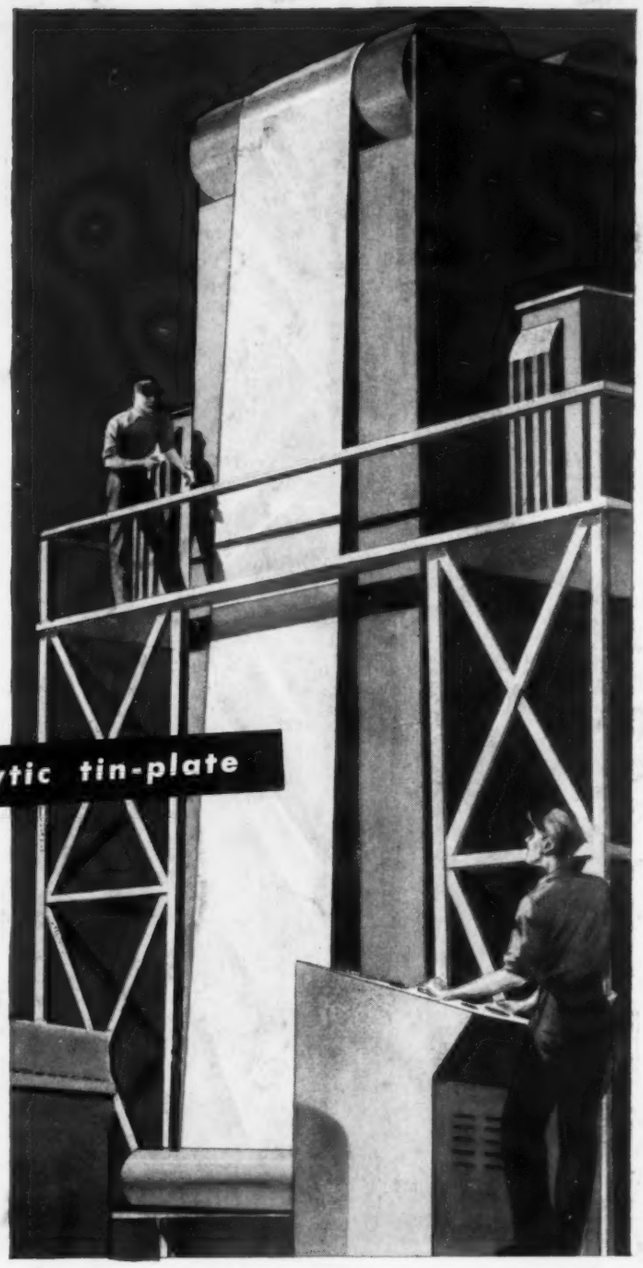
CIRCUIT BREAKER CO., PHILADELPHIA, PA.

THANKS TO A SHORT CIRCUIT



"PRIME SHEET" PRODUCTION *DOUBLED*

in flow-brightening electrolytic tin-plate



On two large tin-plating lines, application of the G-E amplidyne to flow brightening has *more than doubled* the production of prime-quality sheets. Operating speeds have been increased. Rejections have been cut.

The amplidyne provides smooth, fast, sensitive control of the electric power which heats the dull coating of tin just to the flowing point. By keeping this "melting" power constantly in exact proportion to the strip speed, the amplidyne ensures extremely uniform production of high-finish, corrosion-resistant surfaces.

Not only in the steel industry's strikingly successful effort to conserve tin, but on many types of rolling mills, on flying shears and much other equipment, G-E amplidynes have fostered an entirely new concept of automatic control. Our engineers would like to give you details.

Have you read "The Short Circuit That Moves Mountains"? This booklet tells how G-E engineers, in designing the amplidyne, utilized a short circuit, together with load-current compensation, to produce a generator-type amplifier of remarkable versatility. It shows how the amplidyne's 10,000-to -1 amplification and instant responsiveness are achieved. It recounts the amplidyne's accomplishments to date, and forecasts its future. Send for Bulletin GEA-4053. *General Electric Company, Schenectady, N. Y.*

AMPLIDYNES

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